Hydrometeorology Testbed Annual Meeting

Dr. Marty Ralph
NOAA/ESRL/Physical Sciences Division

7 November 2012

ESRL/Physical Sciences Division
Boulder, Colorado

Purpose and Scope

- Provide a venue for a face-to-face gathering of the full HMT team
- Review state of the program
- Review prior year accomplishments/best practices/obstacles
- Review current year plans
- Review transitions-to-operations activities
- Provide a venue for broader HMT team input
- Provide input for FY12 and FY13 HMT Annual Operating Plans

Agenda

Introduction

8:30-9:00 HMT Program Overview - Marty Ralph

Major Activity Area Updates

9:00-10:00 Quantitative Precipitation Estimation (QPE) - Rob Cifelli (Ken Howard)
10:00-10:15 Break
10:15-11:15 Quantitative Precipitation Forecasting (QPF) - Ellen Sukovich (Zoltan Toth)
11:15-12:00 Snow Information (SI) - Allen White (Art Henkel)
12:00-1:00 Lunch (on your own)
1:00-2:00 Hydrologic and Surface Processes (HASP) - Lynn Johnson (Ed Clark)

Transitions to Operations

2:00-2:30 NOAA Hydrometeorological Prediction Center - David Novak
2:30-3:00 NOAA National Water Center - Tim Schneider
3:00-3:15 Break
3:15-4:00 Proposed Decision Support Tools to Aid Forecasters - David Reynolds

Regional Applications

4:00-4:45 HMT- Southeast Overview - Kelly Mahoney
4:45-5:30 HMT- West Overview - Allen White

Adjourn - 5:30

Dinner - 7:30 Boulder Mediterranean Restaurant

Outline

- HMT Overview, Team and Structure
- Selected accomplishments
- Major Activity Area Plans
- Emerging directions

NOAA Hydrometeorology Testbed (HMT)

The Hydrometerology Testbed (HMT) conducts research on precipitation and weather conditions that can lead to flooding, and fosters transition of scientific advances and new tools into forecasting operations. HMT's outputs support efforts to balance water resource demands and flood control in a changing climate. HMT aims to:

- accelerate the development and prototyping of advanced hydrometeorological observations, models, and physical process understanding
- fosters infusion of these advances into operations of the National Weather Service (NWS) and the National Water Center (NWC)
- supports the broader needs for 21st Century precipitation information for flood control, water management, and other applications

NAS and NOAA Drivers

When Weather Matters (Nat'l Academies Press)

- Need for enhanced mesoscale profiling networks to improve forecasts of very high impact events
- Need for improved hydrologic forecast skill and new hydrometeorological observations for model initialization, improvement of model physics, data assimilation , validation

Observing Weather and Climate from the Ground Up (Nat'l Academies Press)

- Importance of observational testbeds as a research to operations tool

NOAA Next Generation Strategic Plan

- *Weather-Ready Nation Goal*
  - Reduced loss of life, property, and disruption from high-impact events
  - Improved freshwater resource management
- *Climate Adaptation and Mitigation Goal*
  - Improved scientific understanding of the changing climate system and its impacts

Key Partners and Stakeholders - NOAA

OAR

- ESRL Physical Sciences Division
- ESRL Global Systems Division
- National Integrated Drought and Information System
- National Severe Storms Laboratory

NESDIS

- Center for Satellite Applications and Research

NWS

- Various Local Weather Forecast Offices
- Various Regional River Forecast Centers
- Various Regional Headquarters Offices
- National Operational Hydrologic Remote Sensing Center
- NCEP Environmental Modeling Center
- Office of Hydrologic Development
- Hydrometeorolgical Prediction Center
- Western Regional Climate Center
- Collaborative Science Technology and Applied Research Program

Key Partners and Stakeholders – Non-NOAA

Federal
- U.S. Army Corps of Engineers
- U.S. Geological Survey

State
- California Department of Water Resources
- Renaissance Computing Institute

Local
- Sacramento Regional Flood Control Agency
- Sonoma County Water Agency

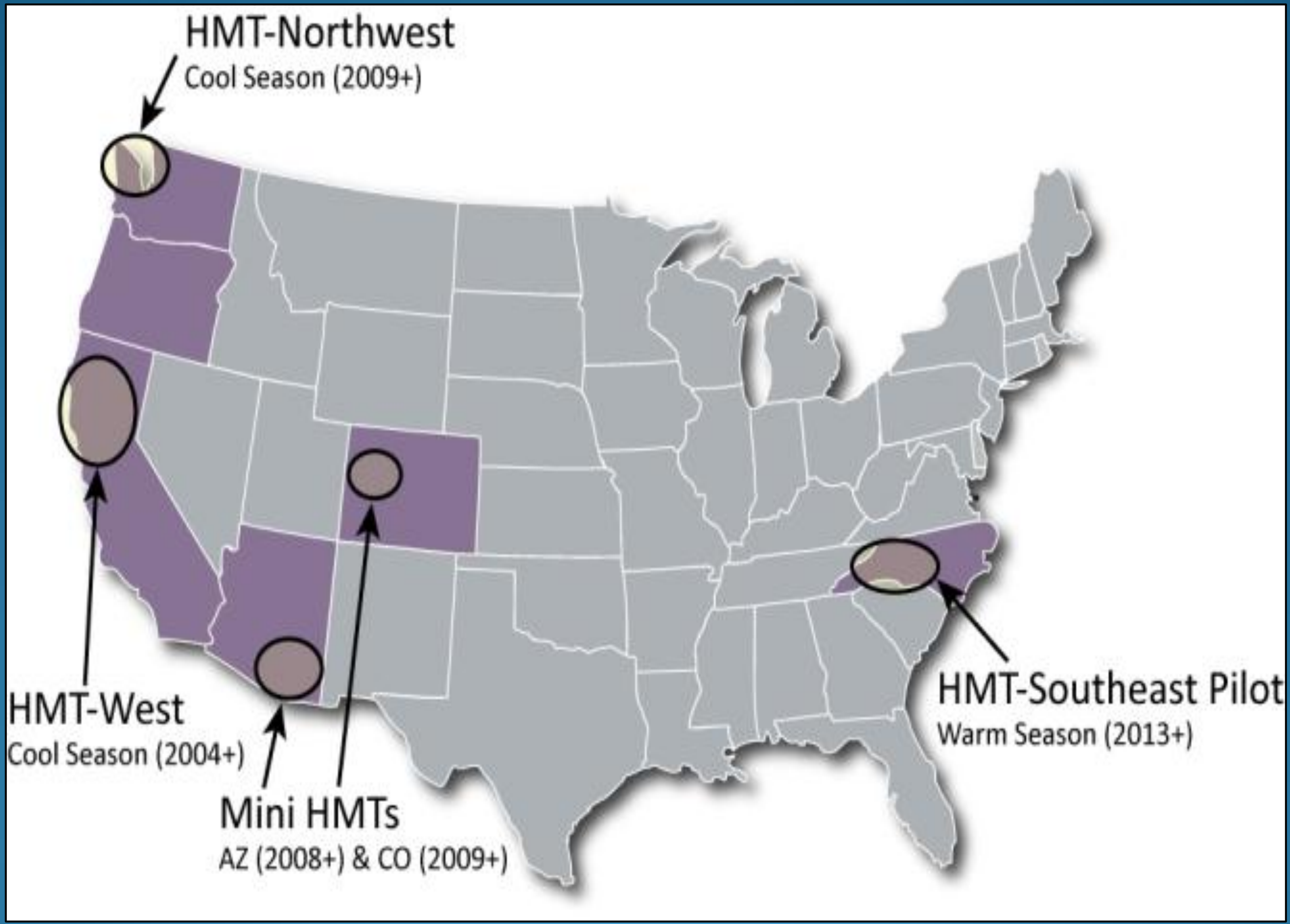
Academic
- UCAR Developmental Testbed Center
- Colorado State University
- University of Colorado
- University of Washington
- Scripps Institution for Oceanography

Related
- California Energy Commission

HMT-West Meeting 2010

Santa Rosa, CA

HMT Locations



HMT Organization

Program Director
Marty Ralph

Program Coordinator
Richard Lataitis

Science Coordinators
Allen White/Rob Cifelli

Field Coordinator
Clark King

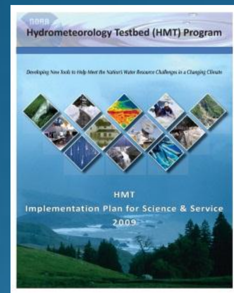
Transition Coordinators
David Reynolds /Tim Schneider

Major Activity Areas

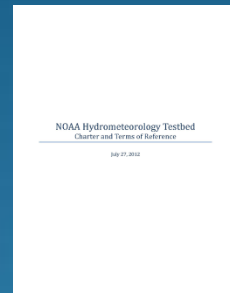
Stakeholder Groups

	Quantitative Precipitation Estimation (QPE)	Quantitative Precipitation Forecasting (QPF)	Snow Information (SI)	Hydrologic and Surface Processes (HASP)	Decision Support Tools (DST)
HMT West/Northwest Allen White/Marty Ralph	Rob Cifelli (OAR/PSD) Ken Howard (OAR/NSSL)	Ellen Sukovich (OAR/PSD) Zoltan Toth (OAR/GSD)	Allen White (OAR/PSD) Art Henkel (NWS/CNRFC)	Lynn Johnson (OAR/PSD) Ed Clark (NWS/OCWWS)	David Reynolds (OAR/PSD) Various WFOs/RFCs
HMT Southeast Rob Cifelli/Kelly Mahoney	Rob Cifelli (OAR/PSD) Ken Howard (OAR/NSSL)	Kelly Mahoney (OAR/PSD) Ellen Sukovich (OAR/PSD)	TBD	TBD	TBD
Transition Activities David Reynolds/Tim Schneider	TBD	Ellen Sukovich (OAR/PSD) David Novak (NWS/HPC)	Allen White (OAR/PSD) Art Henkel (NWS/CNRFC)	TBD	TBD

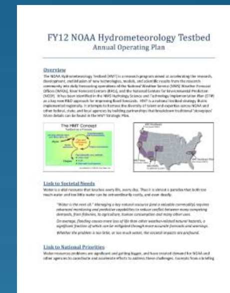
Guiding Documents



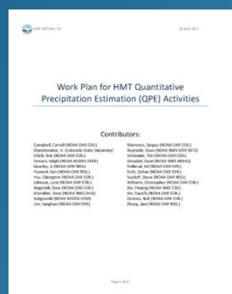
Strategic Plan



Charter

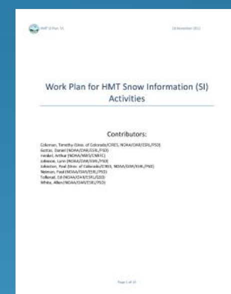


AOP

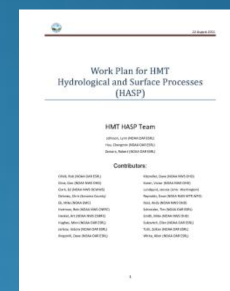


5-yr QPE Plan

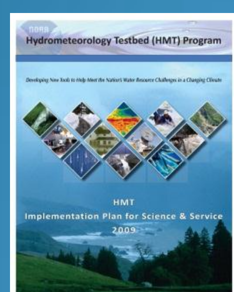
5-yr QPF Plan



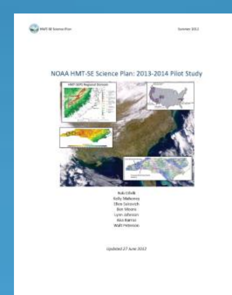
5-yr SI Plan



5-yr HASP Plan



HMT-West Plan



HMT-SE Plan

Transition Plan

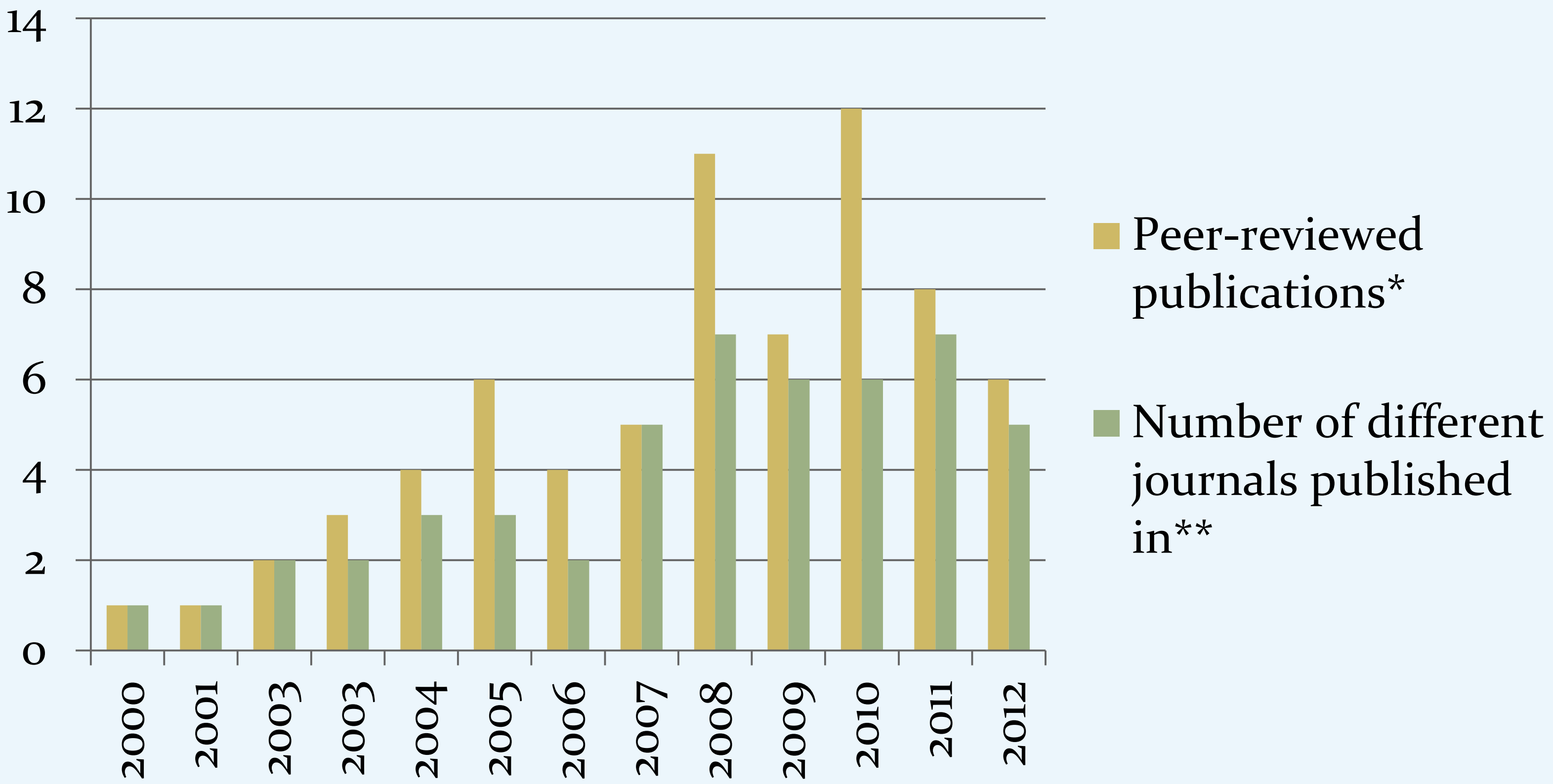
HMT Hydrometeorology Testbed

NOAA

hmt.noaa.gov

"HMT News" Stories added every 1-2 weeks

HMT Uses Scientific Peer Review to Ensure Results Have A Solid Scientific Foundation and Multidisciplinary Impacts

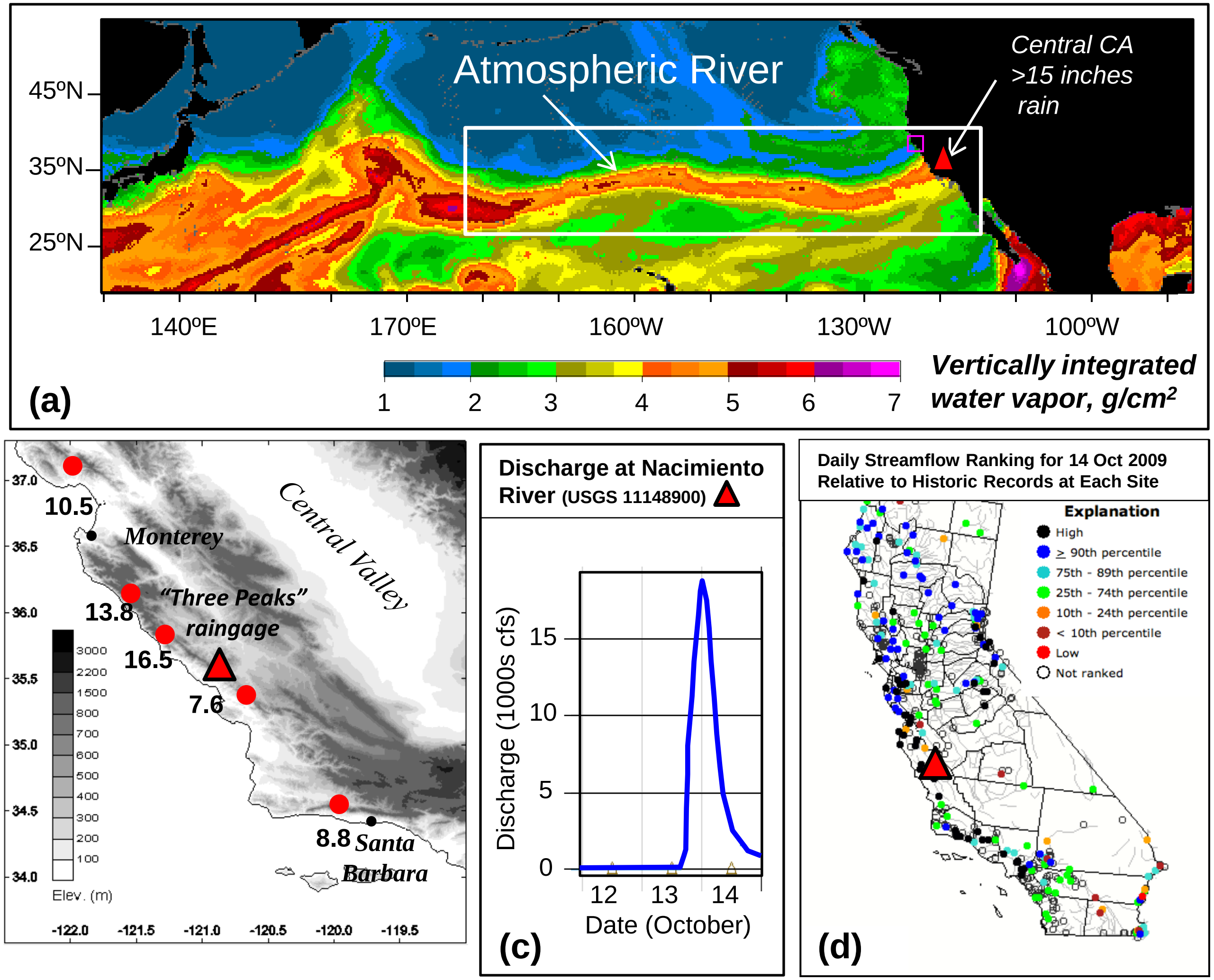


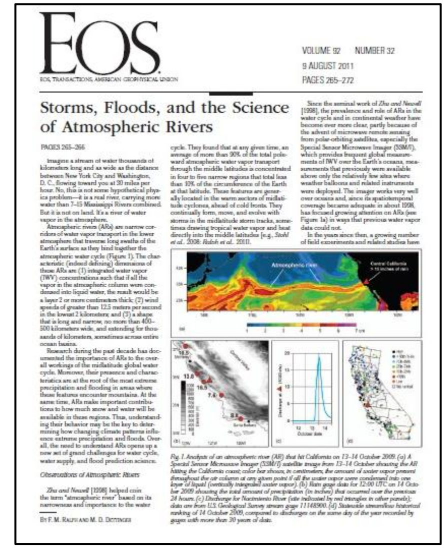
*Papers must have used data or model information directly from HMT or its predecessors CALJET and PACJET (full bibliography with these 70 publications is available at hmt.noaa.gov)

**Journals published in (15): Geophys. Res. Lett., J. Hydrometeor., Mon. Wea. Rev., J. Tech., Water Resources Research, Water Management, J. Climate, Bull. Amer. Meteor. Soc, Weather and Forecast, IEEE Trans. Geoscience and Remote Sensing, etc…

Selected Accomplishments

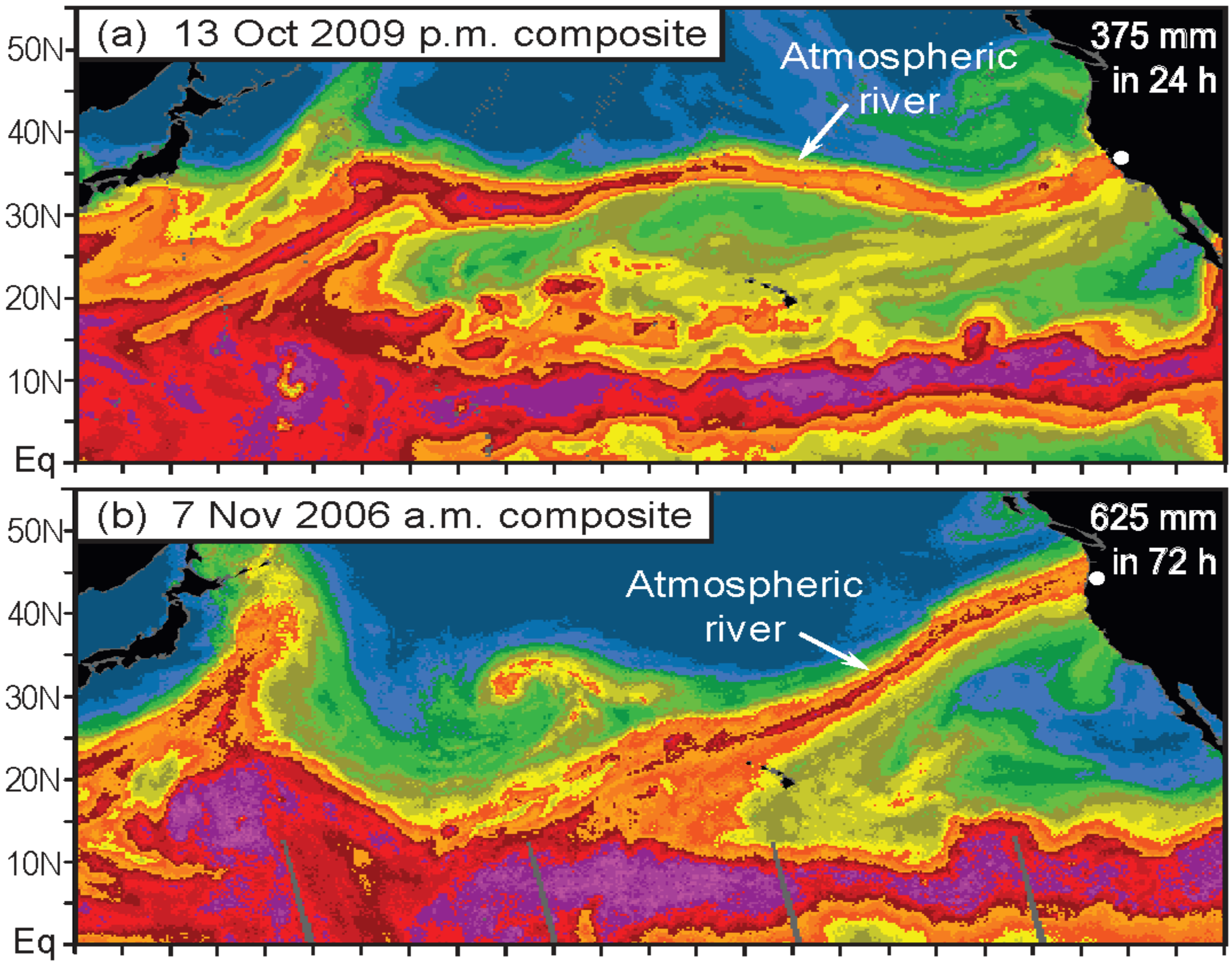
Research has Identified Atmospheric Rivers as the Primary Meteorological Cause of Extreme Precipitation & Flooding on U.S. West Coast




EOS
VOLUME 92 NUMBER 32
9 AUGUST 2011
PAGES 265–272
Storms, Floods, and the Science of Atmospheric Rivers

Ralph, F.M., and M.D. Dettinger, 2011: Storms, Floods and the Science of Atmospheric Rivers. *EOS, Transactions, Amer. Geophys. Union.*, **92**, 265-266.

Atmospheric rivers: SSM/I Satellite data for two recent examples that produced extreme rainfall and flooding



These color images represent satellite observations of atmospheric water vapor over the oceans.

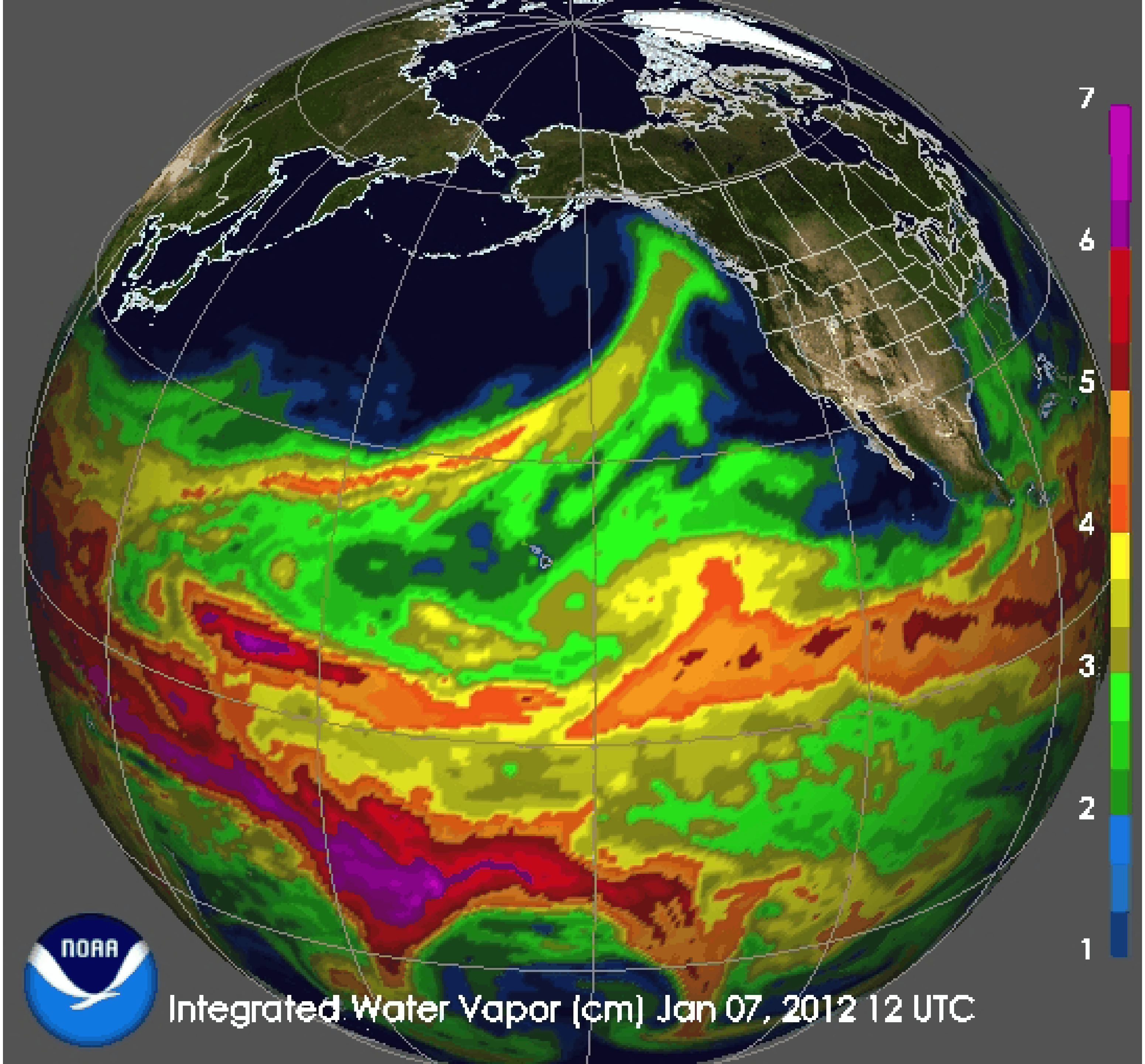
Warm colors = moist air
Cool colors = dry air

ARs can be detected with these data due to their distinctive spatial pattern.

In the top panel, the AR hit central California and produced 18 inches of rain in 24 hours.

In the bottom panel, the AR hit the Pacific Northwest and stalled, creating over 25 inches of rain in 3 days.

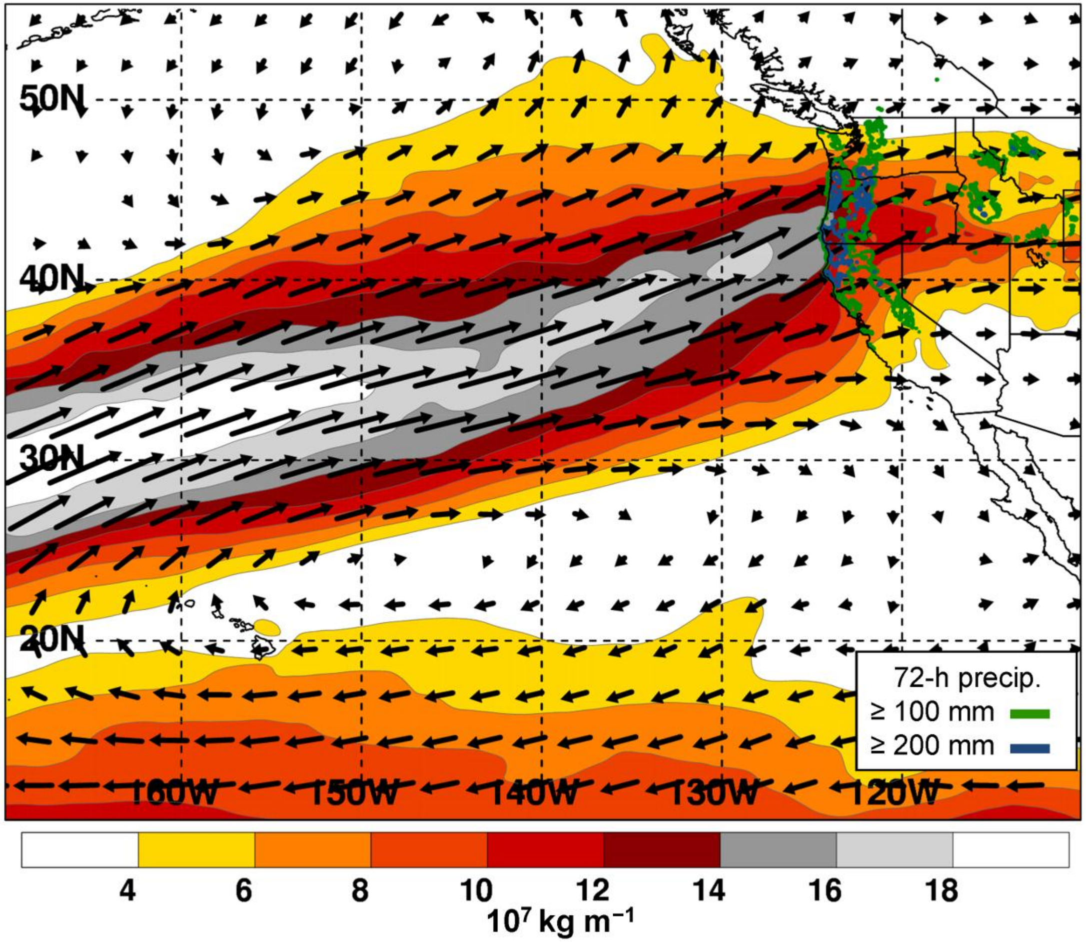
From Ralph et al. 2011, Mon. Wea. Rev.

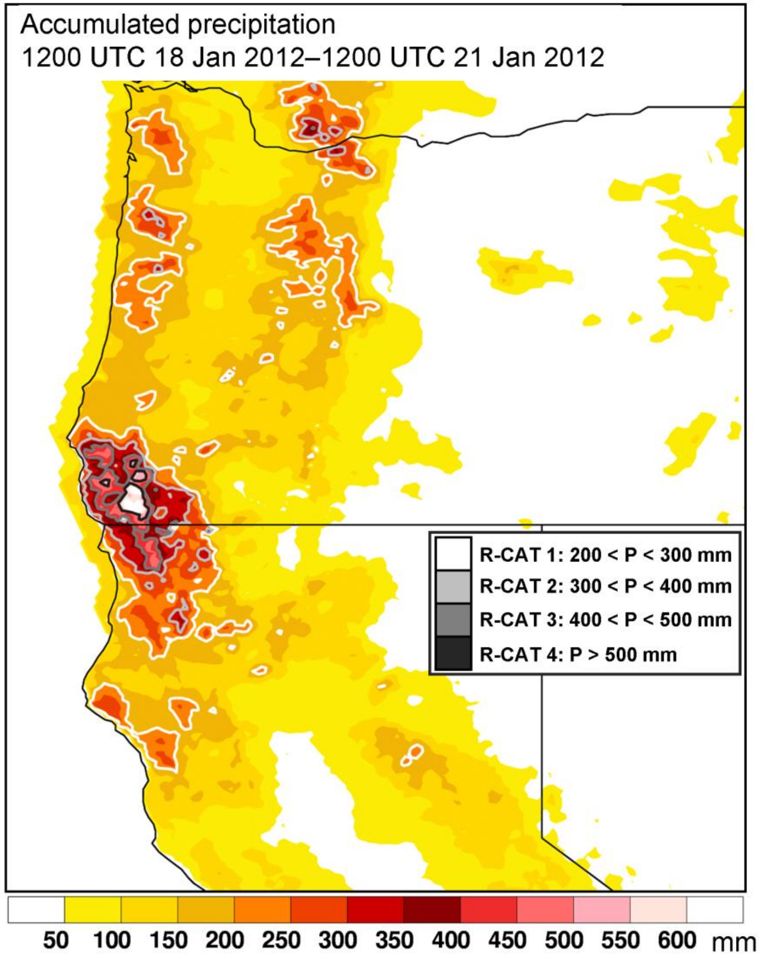

7
6
5
4
3
2
1
NOAA
Integrated Water Vapor (cm) Jan 07, 2012 12 UTC

18–21 Jan 2012 AR Event *(analysis courtesy of Ben Moore, Jay Cordeira)*

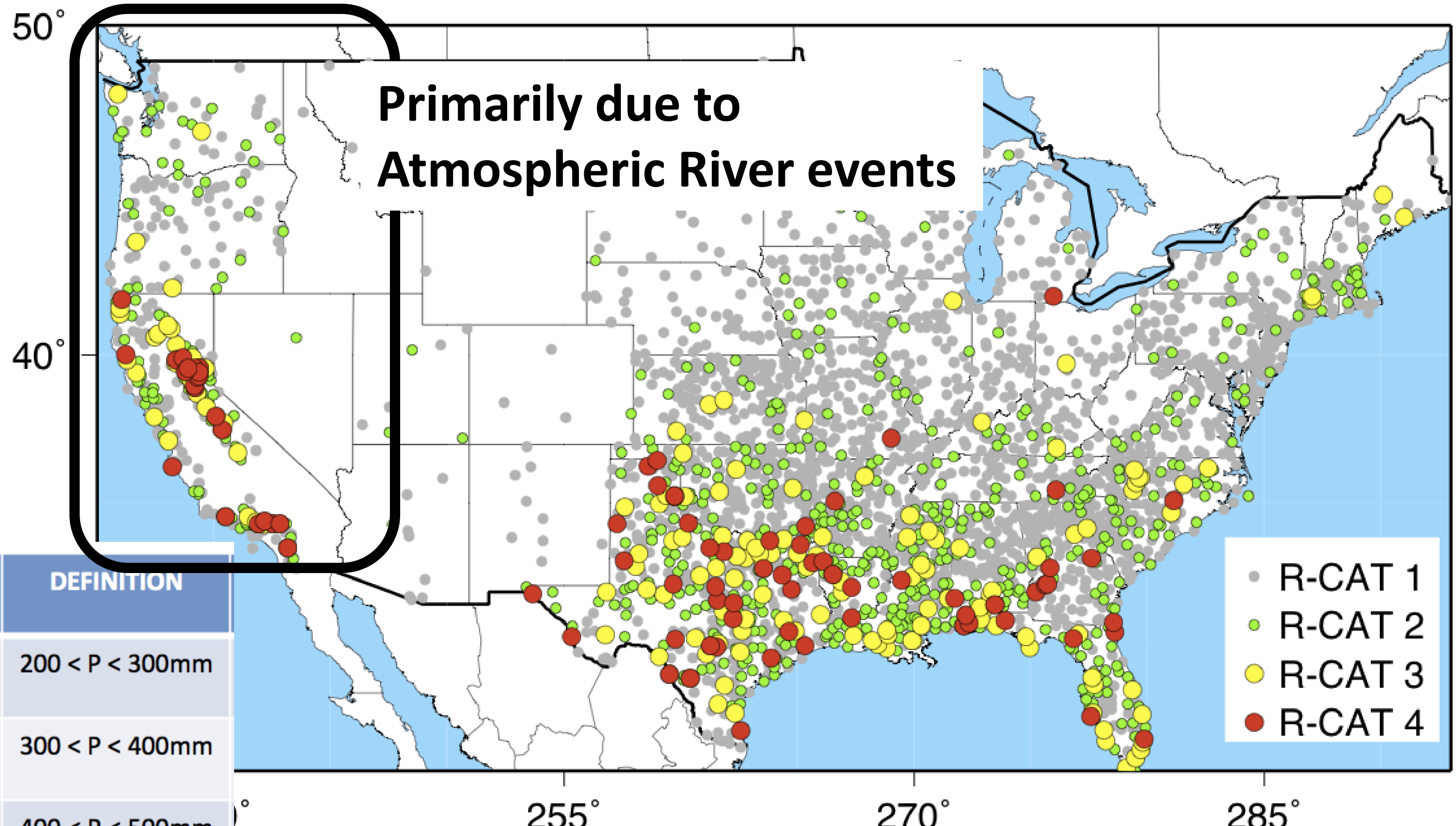
- The long duration of AR conditions in Oregon and northern California supported widespread heavy rainfall
- 72-h precipitation totals exceeding 100 mm were common along the west coast, with largest amounts observed in southwestern Oregon and northwestern CA
- Localized precip. totals ranged from 400 mm to >500 mm (R-CATs 3–4) in this region

Time-integrated IVT 12 UTC 18 Jan–12 UTC 21 Jan





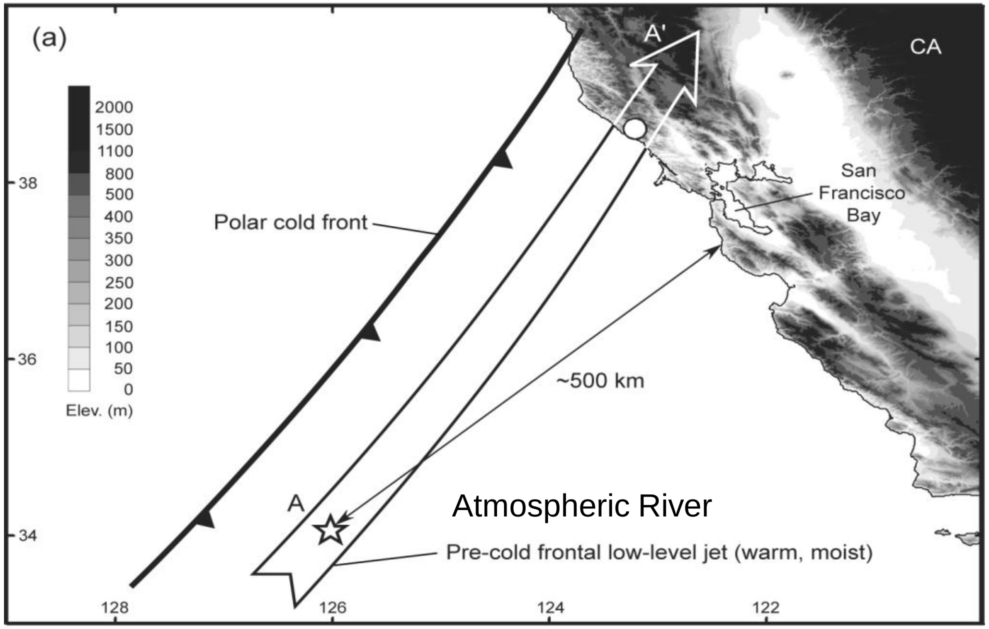
LARGEST 3-DAY PRECIPITATION TOTALS, 1950-2008

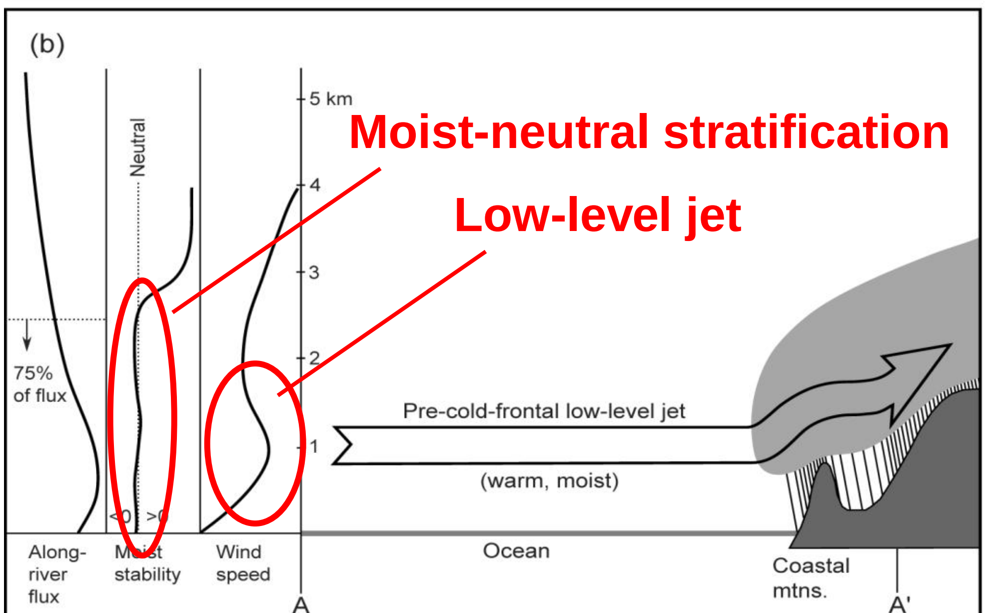


R-CAT	DEFINITION
1	200 < P < 300mm
2	300 < P < 400mm
3	400 < P < 500mm
4	P > 500mm

Ralph, F.M., and Dettinger, M.D., Historical and national perspectives on extreme west-coast precipitation associated with atmospheric rivers during December 2010: Bulletin of the American Meteorological Society, (in press, Nov 2011)

Vertical structure documented offshore





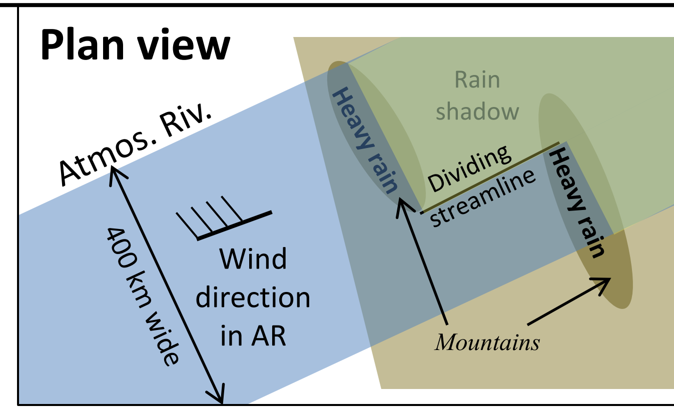
Dropsonde observations in low-level jets over the Northeastern Pacific Ocean from CALJET-1998 and PACJET-2001

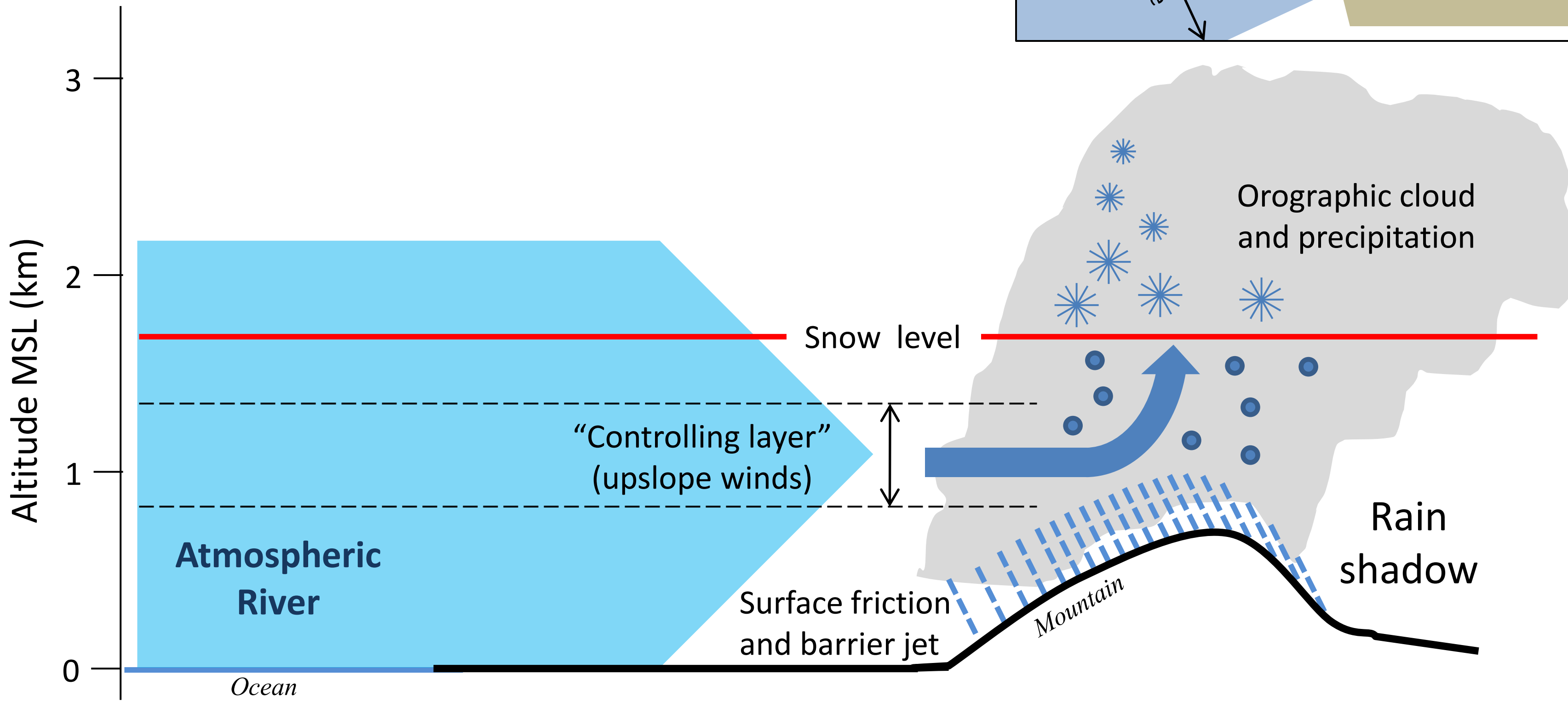
Ralph, F. M., P. J., Neiman and R. Rotunno

Mon. Wea. Rev., 2005

- 17 research aircraft missions offshore of CA documented atmospheric river structure.
- Wind, water vapor and static stability within atmospheric rivers are ideal for creation of heavy rainfall when they strike coastal mountains.
- These characteristics were present in both El Nino and Neutral winters

Key Features Associated with Atmospheric Rivers and Orographic Precipitation





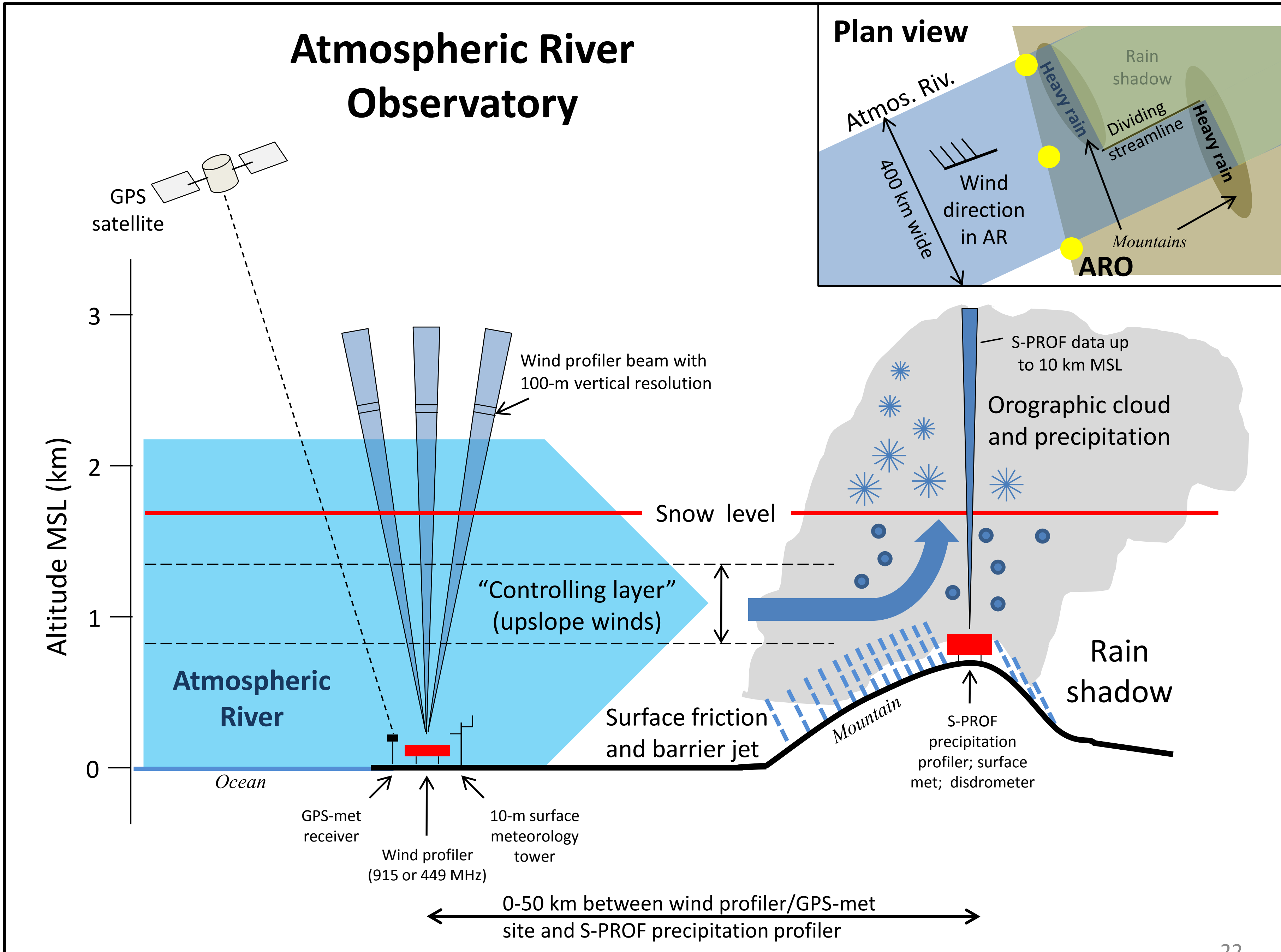
Physical conditions required for extreme precipitation

Wind in the controlling layer near 1 km MSL
speed > 12.5 m/s, and preferred direction

Water vapor content
vertically integrated water vapor (IWV) > 2 cm

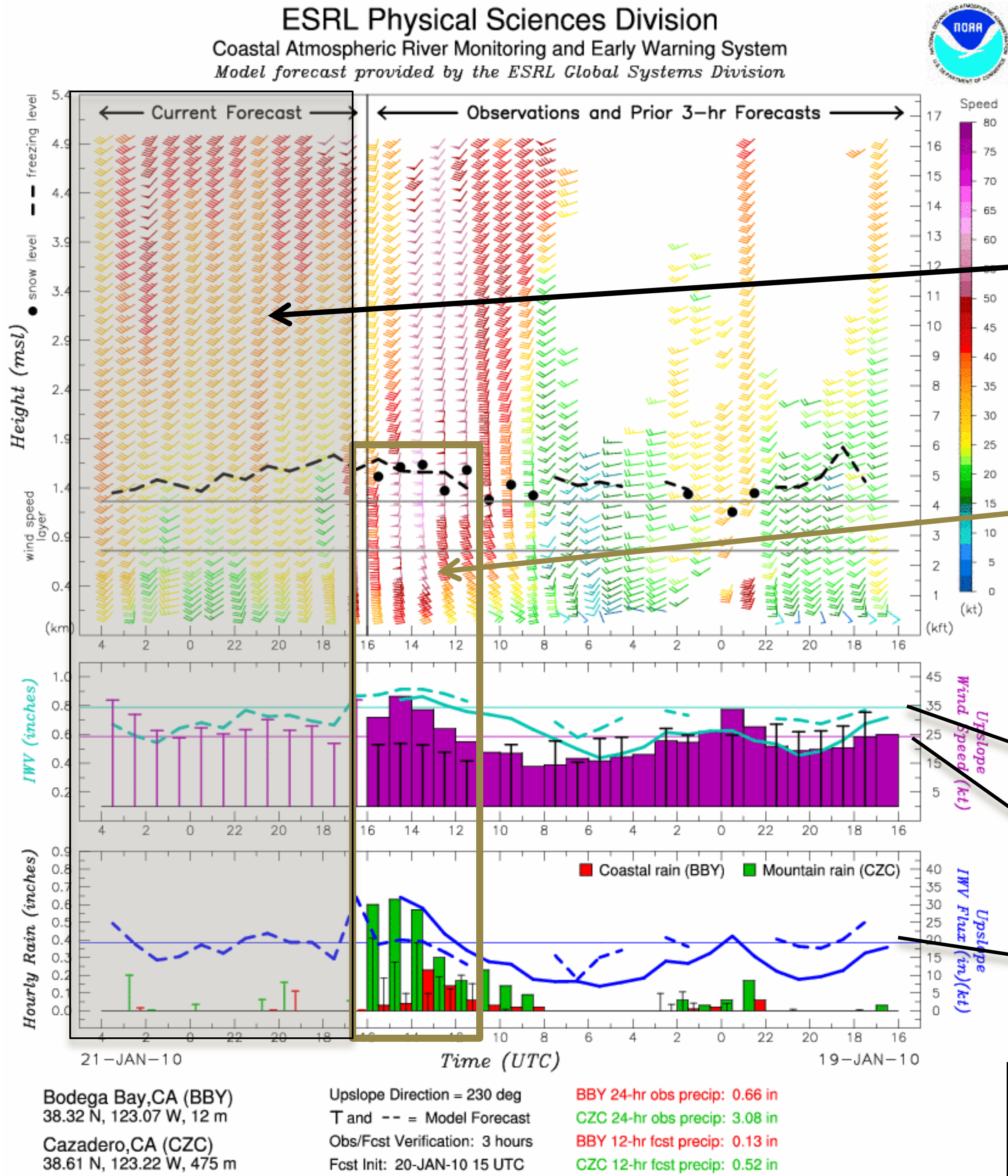
Snow level
Above top of watershed

Atmospheric River Observatory



ARO Flux tool

- available real time



Model forecasts

AR conditions detected at Bodega Bay by ARO:
GPS-Met IWV > 2 cm,
Low-level jet >50 kt
Heavy rain >0.5 in/hr

IWV

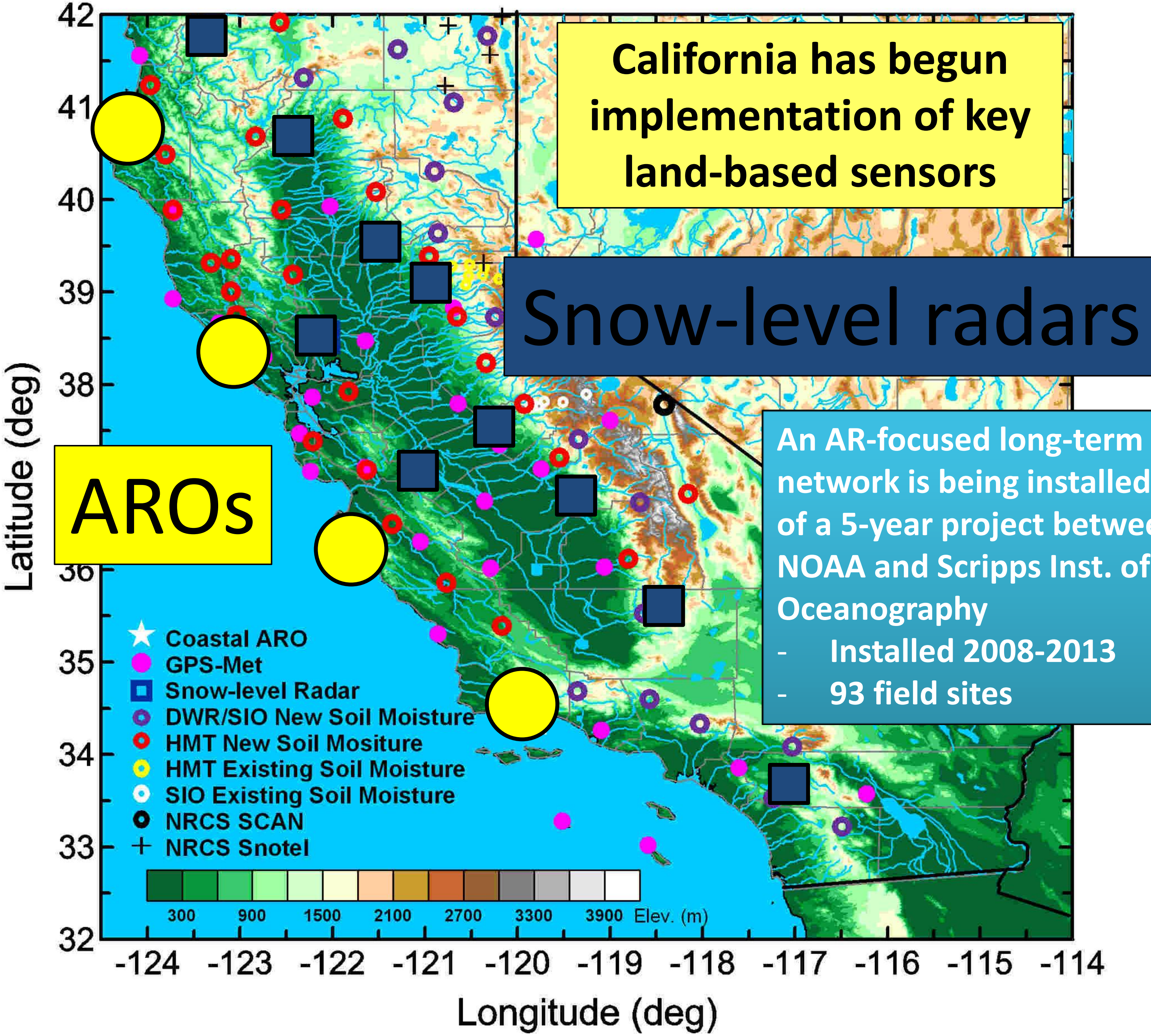
Upslope wind

“Bulk” Vapor transport

Uses objective thresholds

Neiman et al., 2009
J. Water Management

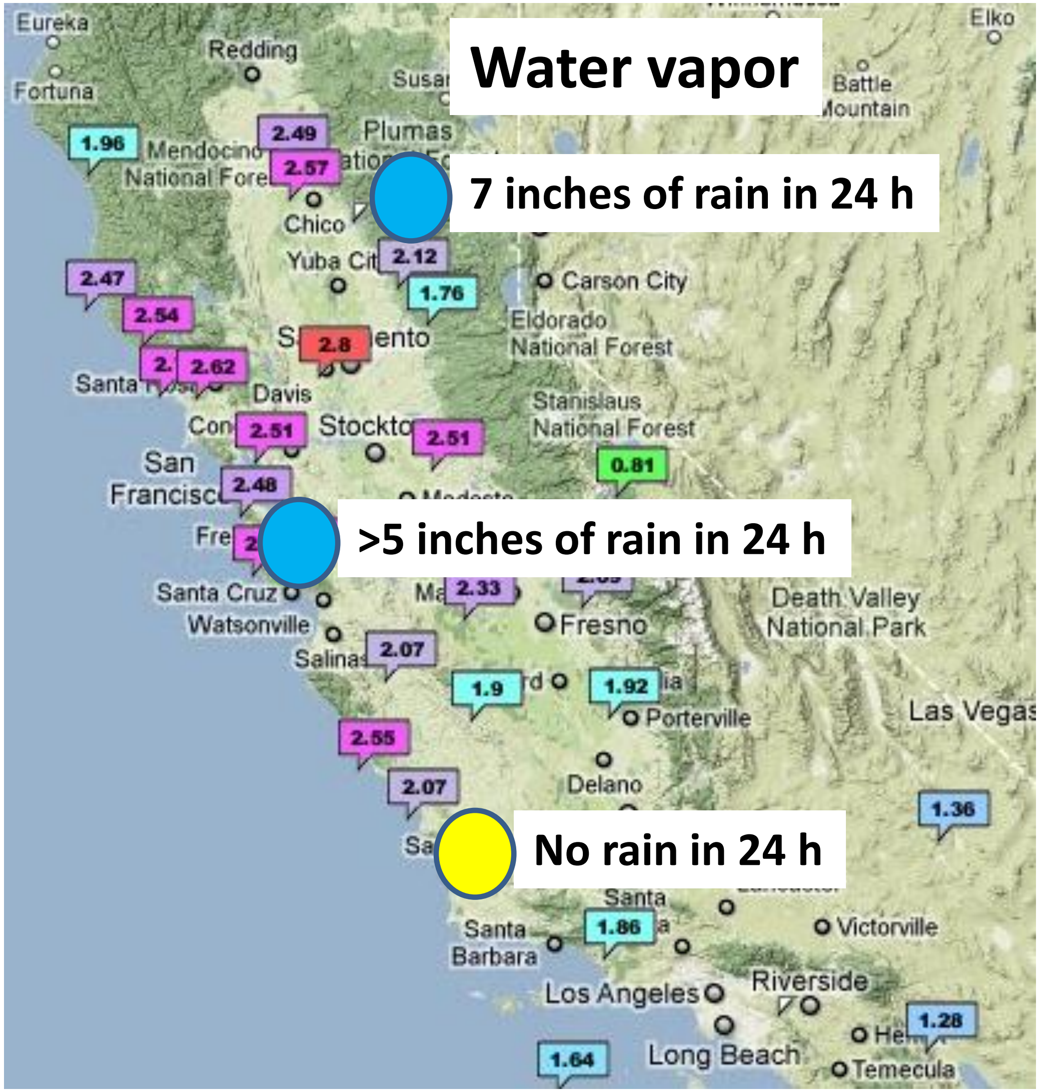
California has begun implementation of key land-based sensors



An AR-focused long-term observing network is being installed in CA as part of a 5-year project between CA-DWR, NOAA and Scripps Inst. of Oceanography

- Installed 2008-2013
- 93 field sites

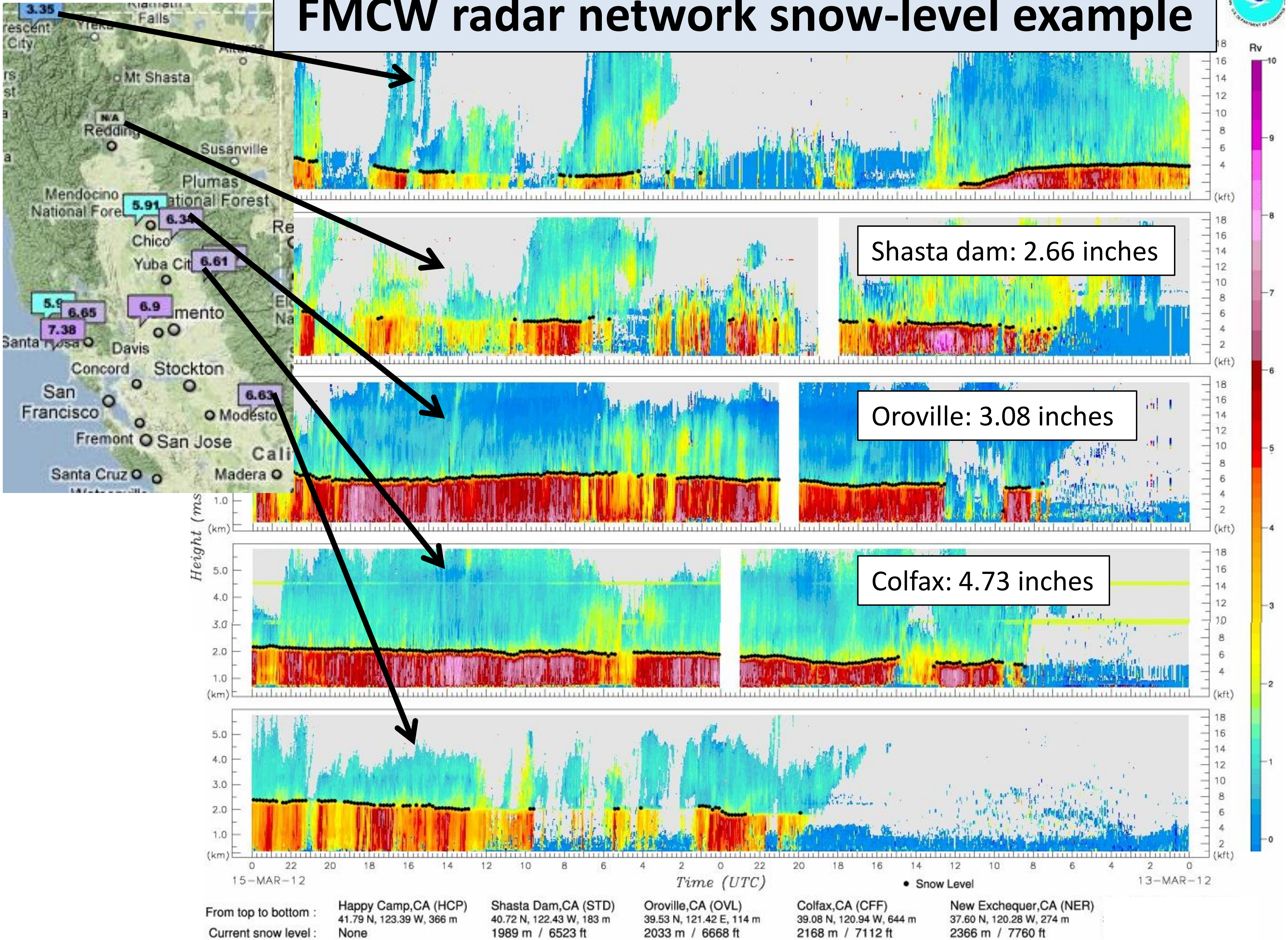
New observations on 13 March 2012

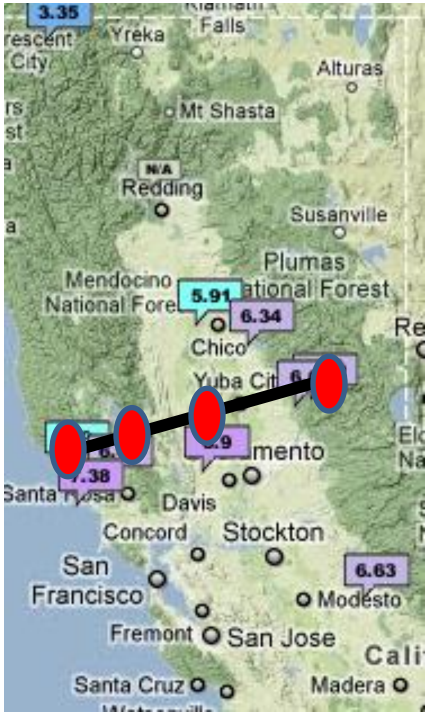


Vertically integrated water vapor (cm)

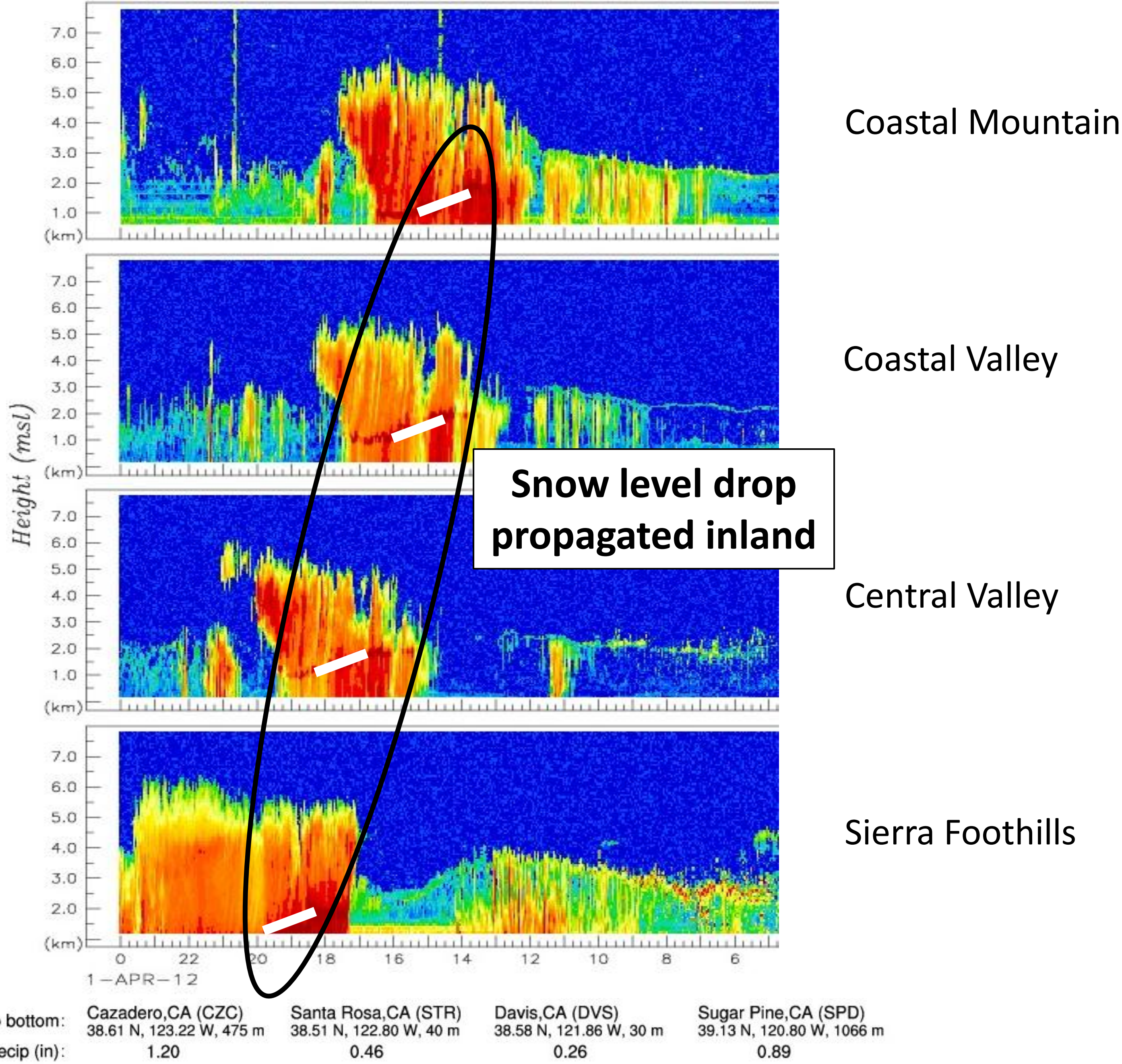
Snow level observing network showing the "snow level" in 1000's of feet above sea level. The snow level is the altitude above which precipitation is occurring as snow at that place and time.

FMCW radar network snow-level example





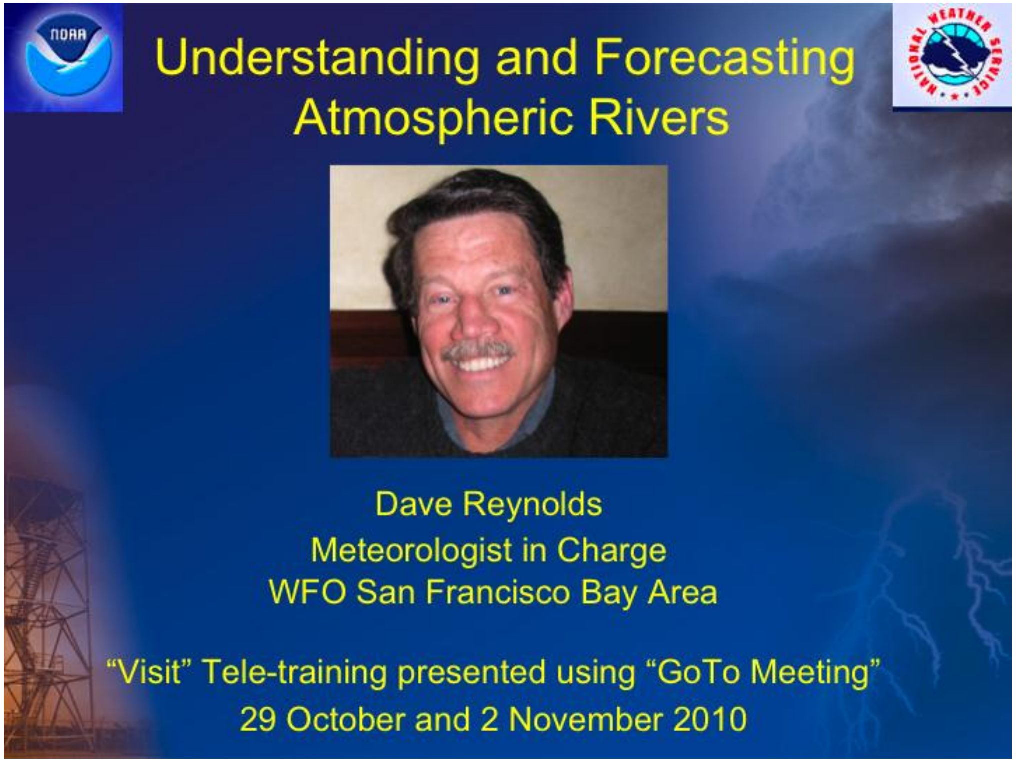
3.35
Yreka
Falls
Crescent City
Alturas
Mt Shasta
N/A
Redding
Susanville
Plumas National Forest
Mendocino National Fore
5.91
6.34
Chico
Yuba Cit
mento
7.38
Santa Rosa
Davis
Concord
Stockton
San Francisco
6.63
Modesto
Fremont
San Jose
Santa Cruz
Madera



Coastal Mountain
Coastal Valley
Central Valley
Sierra Foothills
Snow level drop propagated inland
Height (msl)
(km)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
22
20
18
16
14
12
10
8
6
1-APR-12
From top to bottom:
Cazadero,CA (CZC) 38.61 N, 123.22 W, 475 m
Santa Rosa,CA (STR) 38.51 N, 122.80 W, 40 m
Davis,CA (DVS) 38.58 N, 121.86 W, 30 m
Sugar Pine,CA (SPD) 39.13 N, 120.80 W, 1066 m
48-hour precip (in):
1.20
0.46
0.26
0.89

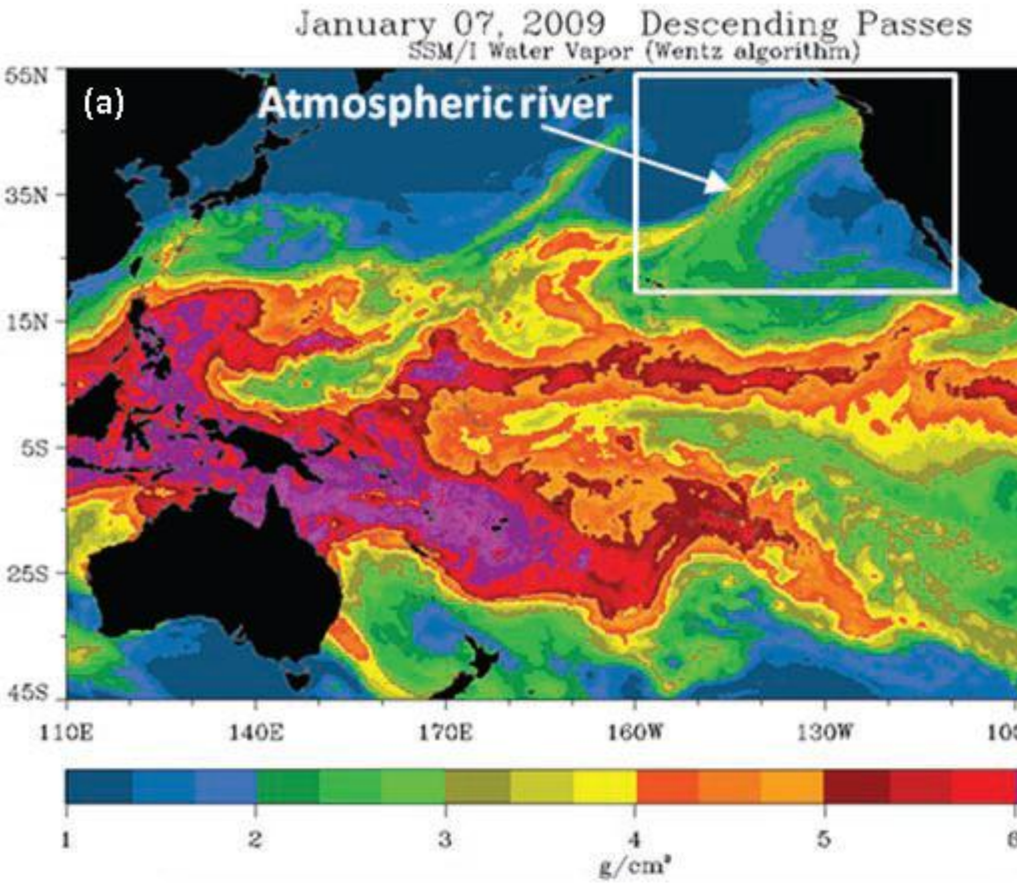
Forecasting Atmospheric Rivers

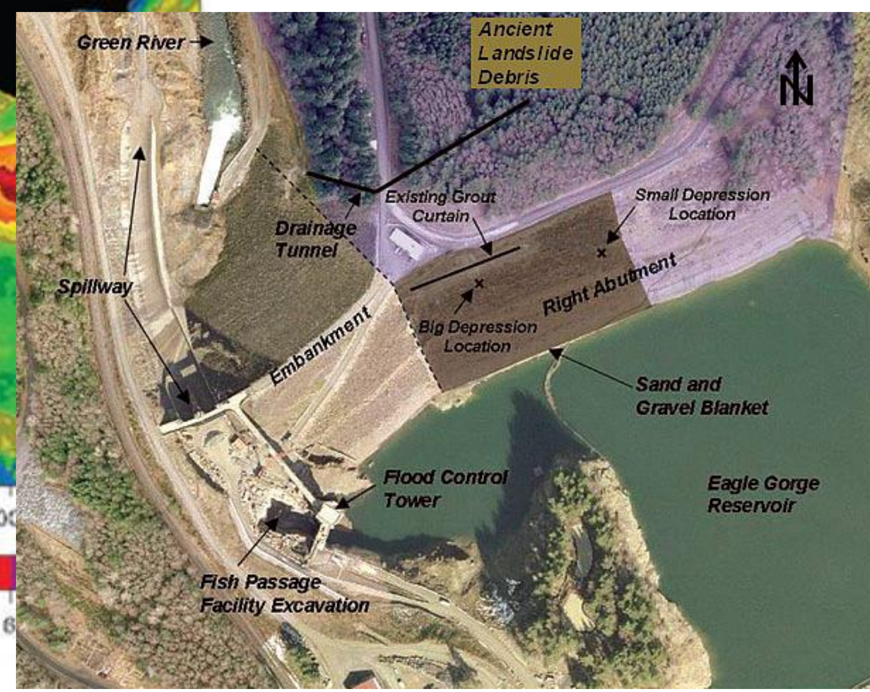
HMT Findings used in NWS Training



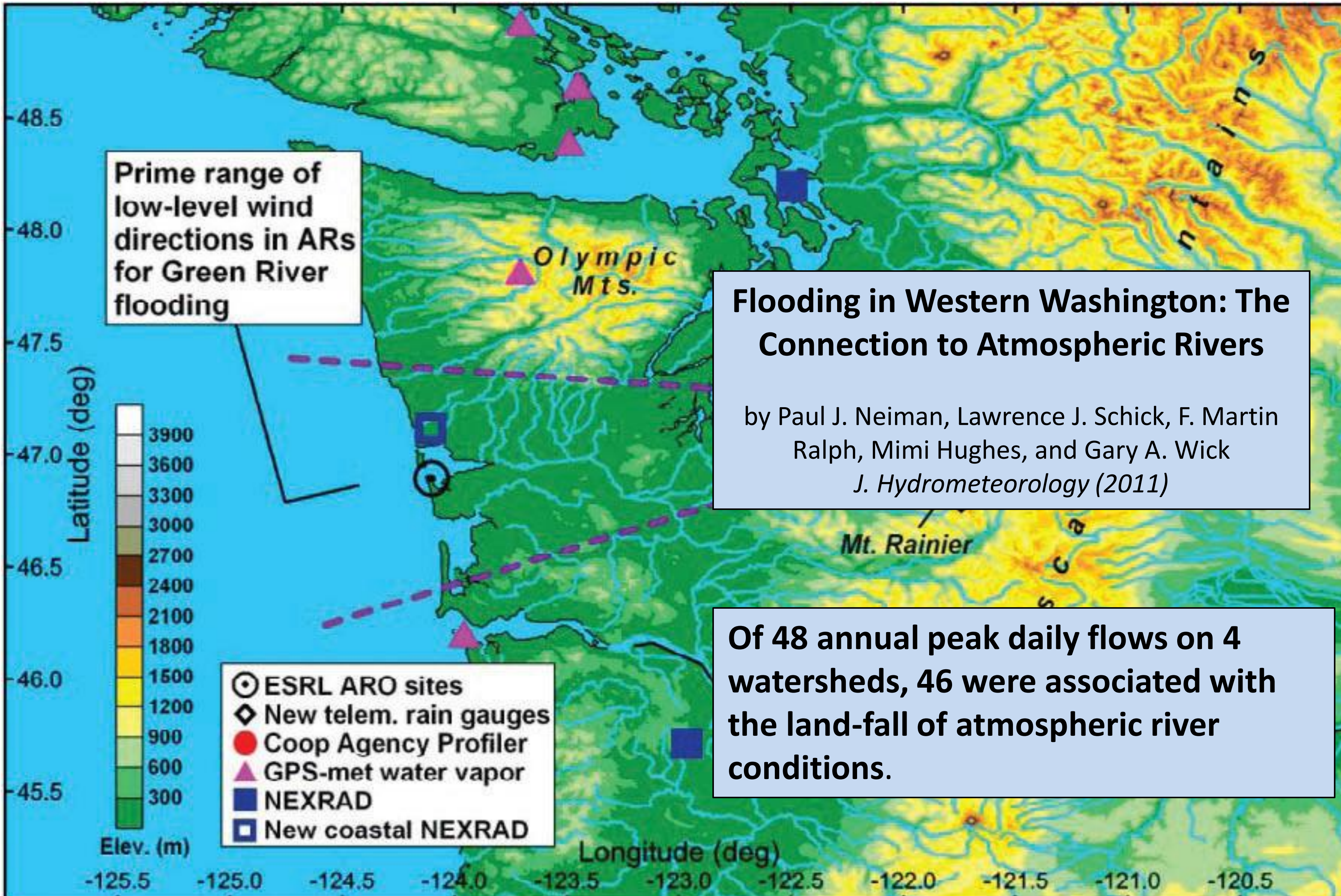
- Improved situational awareness
- Advance lead time that a "big event" may be coming, a few days ahead
- Details on locations, timing and strength improve as event nears, but precipitation amounts are generally underpredicted

Howard Hanson Dam Damaged by Storm in January 2007





NOAA/HMT Contributed new AR-related methods as part of a broad multi-agency rapid response

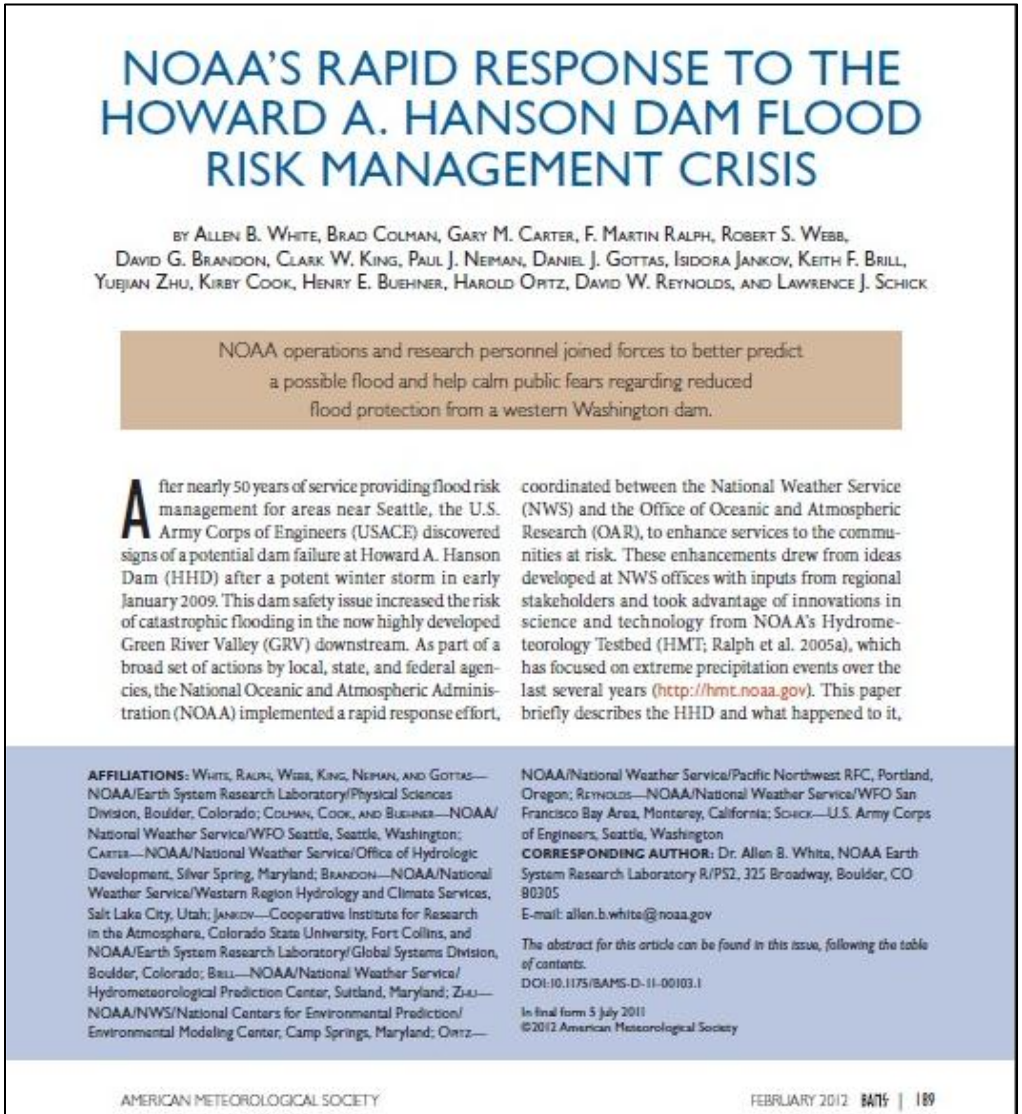


Flooding in Western Washington: The Connection to Atmospheric Rivers

by Paul J. Neiman, Lawrence J. Schick, F. Martin Ralph, Mimi Hughes, and Gary A. Wick
J. Hydrometeorology (2011)

Of 48 annual peak daily flows on 4 watersheds, 46 were associated with the land-fall of atmospheric river conditions.

This rapid response effort led to many lasting lessons, including demonstration of use of ARO data by the US Army Corps of Engineers (USACE)



NOAA'S RAPID RESPONSE TO THE HOWARD A. HANSON DAM FLOOD RISK MANAGEMENT CRISIS

BY ALLEN B. WHITE, BRAD COLMAN, GARY M. CARTER, F. MARTIN RALPH, ROBERT S. WEBB, DAVID G. BRANDON, CLARK W. KING, PAUL J. NEIMAN, DANIEL J. GOTTAS, ISIDORA JANKOV, KEITH F. BRILL, YUEJIAN ZHU, KIRBY COOK, HENRY E. BUEHNER, HAROLD OPITZ, DAVID W. REYNOLDS, AND LAWRENCE J. SCHICK

NOAA operations and research personnel joined forces to better predict a possible flood and help calm public fears regarding reduced flood protection from a western Washington dam.

After nearly 50 years of service providing flood risk management for areas near Seattle, the U.S. Army Corps of Engineers (USACE) discovered signs of a potential dam failure at Howard A. Hanson Dam (HHD) after a potent winter storm in early January 2009. This dam safety issue increased the risk of catastrophic flooding in the now highly developed Green River Valley (GRV) downstream. As part of a broad set of actions by local, state, and federal agencies, the National Oceanic and Atmospheric Administration (NOAA) implemented a rapid response effort, coordinated between the National Weather Service (NWS) and the Office of Oceanic and Atmospheric Research (OAR), to enhance services to the communities at risk. These enhancements drew from ideas developed at NWS offices with inputs from regional stakeholders and took advantage of innovations in science and technology from NOAA's Hydrometeorology Testbed (HMT; Ralph et al. 2005a), which has focused on extreme precipitation events over the last several years (http://hmt.noaa.gov). This paper briefly describes the HHD and what happened to it,

AFFILIATIONS: WHITE, RALPH, WEBB, KING, NEIMAN, AND GOTTAS—NOAA/Earth System Research Laboratory/Physical Sciences Division, Boulder, Colorado; COLMAN, COOK, AND BUEHNER—NOAA/National Weather Service/WFO Seattle, Seattle, Washington; CARTER—NOAA/National Weather Service/Office of Hydrologic Development, Silver Spring, Maryland; BRANDON—NOAA/National Weather Service/Western Region Hydrology and Climate Services, Salt Lake City, Utah; JANKOV—Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, and NOAA/Earth System Research Laboratory/Global Systems Division, Boulder, Colorado; BRILL—NOAA/National Weather Service/Hydrometeorological Prediction Center, Suitland, Maryland; ZHU—NOAA/NWS/National Centers for Environmental Prediction/Environmental Modeling Center, Camp Springs, Maryland; OPITZ—NOAA/National Weather Service/Pacific Northwest RFC, Portland, Oregon; REYNOLDS—NOAA/National Weather Service/WFO San Francisco Bay Area, Monterey, California; SCHICK—U.S. Army Corps of Engineers, Seattle, Washington

CORRESPONDING AUTHOR: Dr. Allen B. White, NOAA Earth System Research Laboratory R/PS2, 325 Broadway, Boulder, CO 80305

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The abstract for this article can be found in this issue, following the table of contents.

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In final form 5 July 2011

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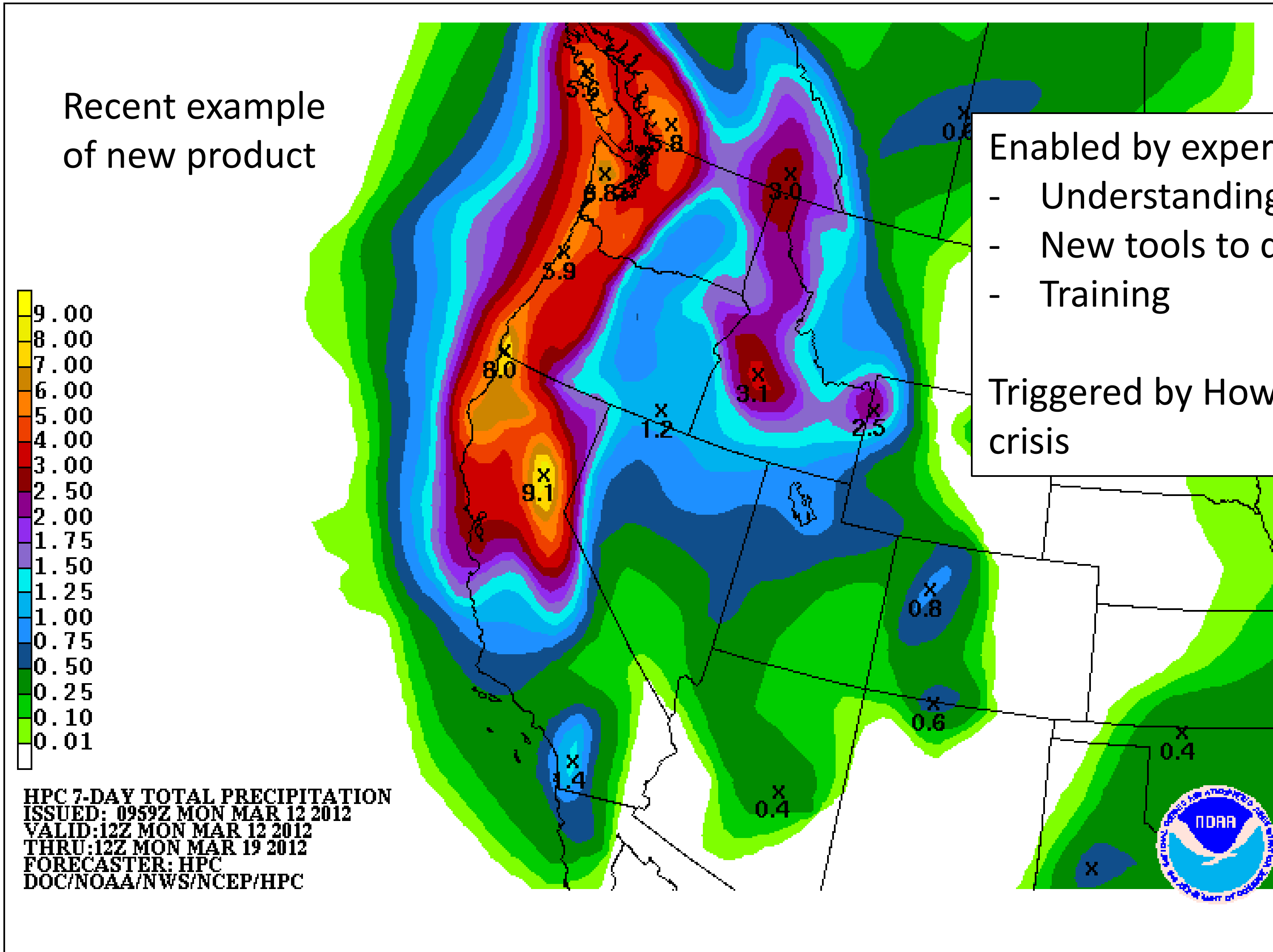
- USACE was considering taking over operation of a dam in Washington State during a recent storm.
- Using the HMT ARO at the coast and NWS forecasts, USACE saw the back edge of the AR was coming ashore and thus heavy rain was about to end, so they did not take over operation from the local water agency.
- See recent journal article by White et al. (February 2012; Bulletin of the American Meteorological Society).

HPC introduced new forecast product - 7-day QPF

Recent example of new product



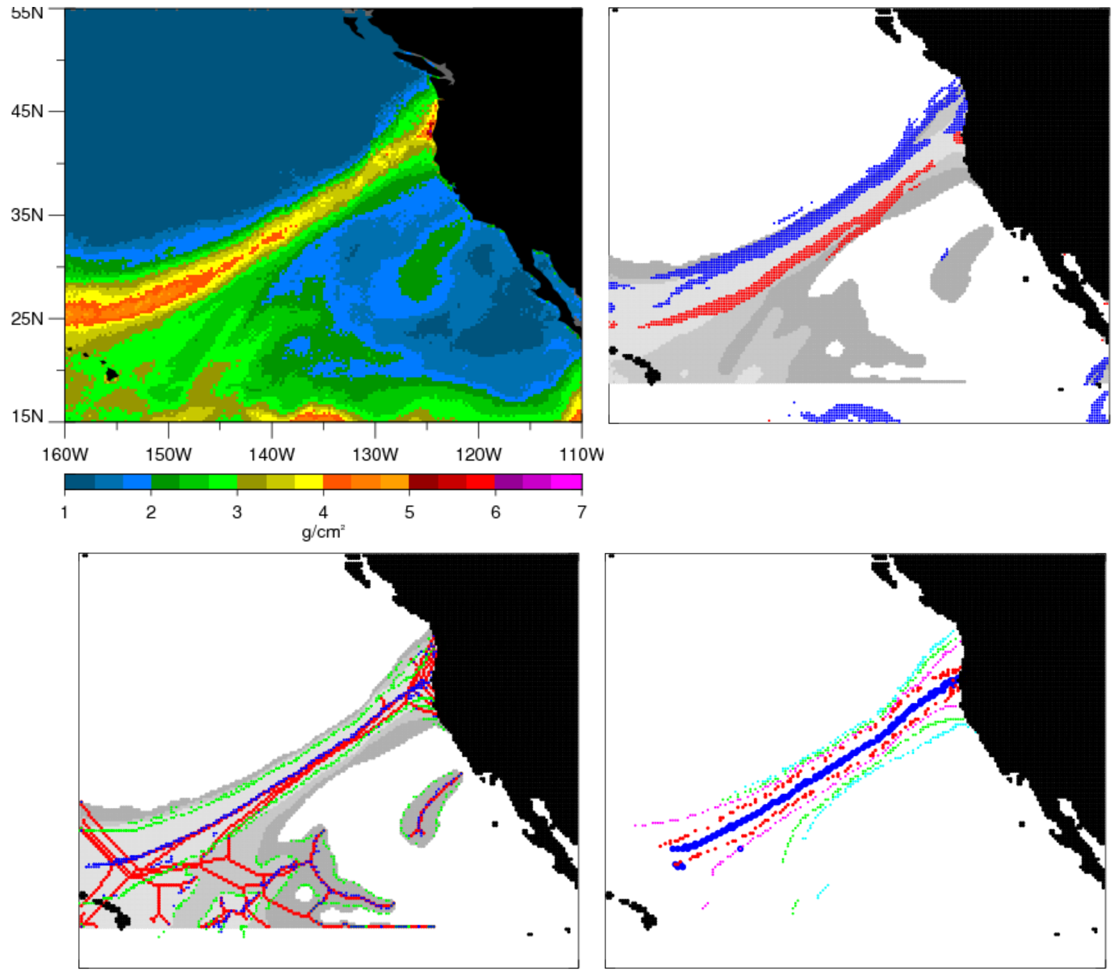
Enabled by experiences from HMT:

- Understanding of ARs
- New tools to quantify ARs
- Training

Triggered by Howard Hanson Dam crisis

Objective AR Identification Procedure

- Isolate top of the tropical water vapor reservoir
- Threshold IWV values at multiple levels and compute gradients
- Cluster points above thresholds and compute skeleton to estimate axis
- Identify points satisfying width criteria
- Cluster center points to identify segments of sufficient length
- Extract AR characteristics
- Determine if AR intersects land or is potentially influenced by data gaps

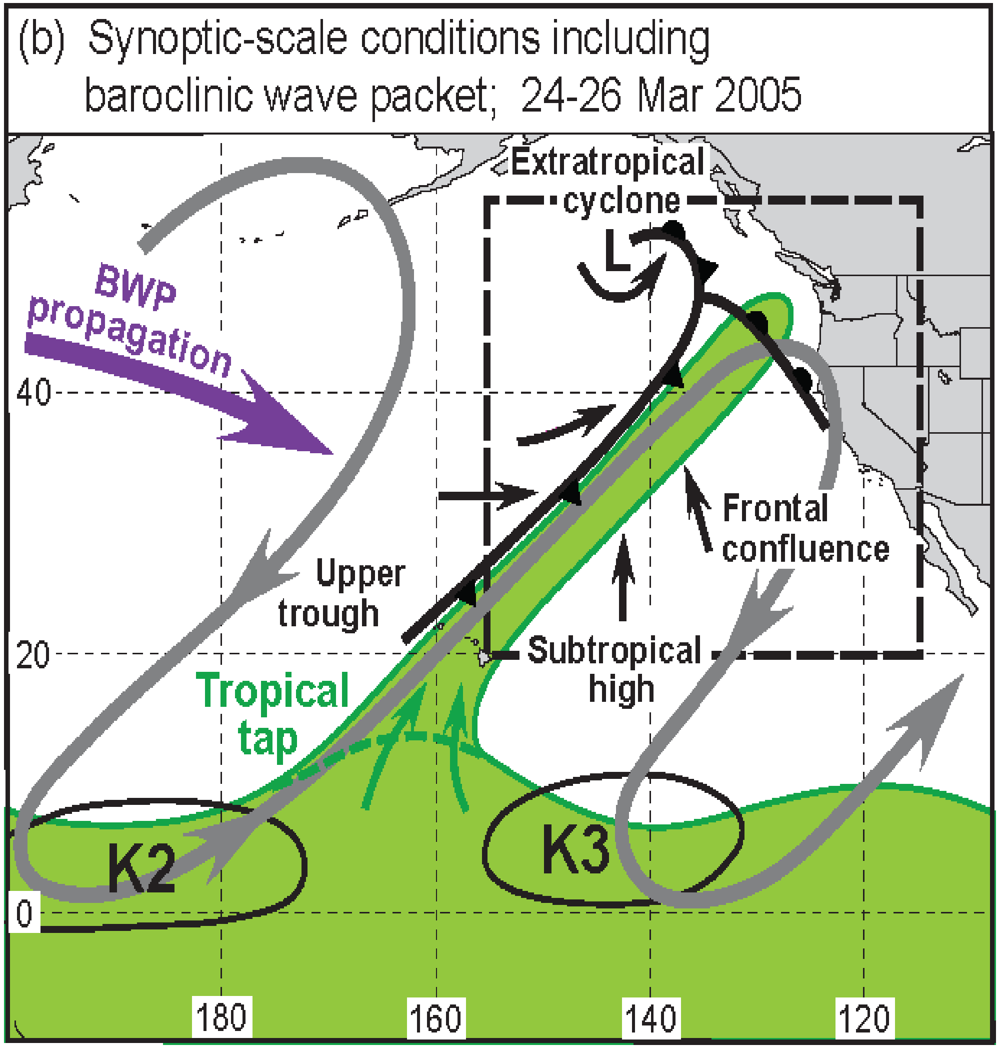


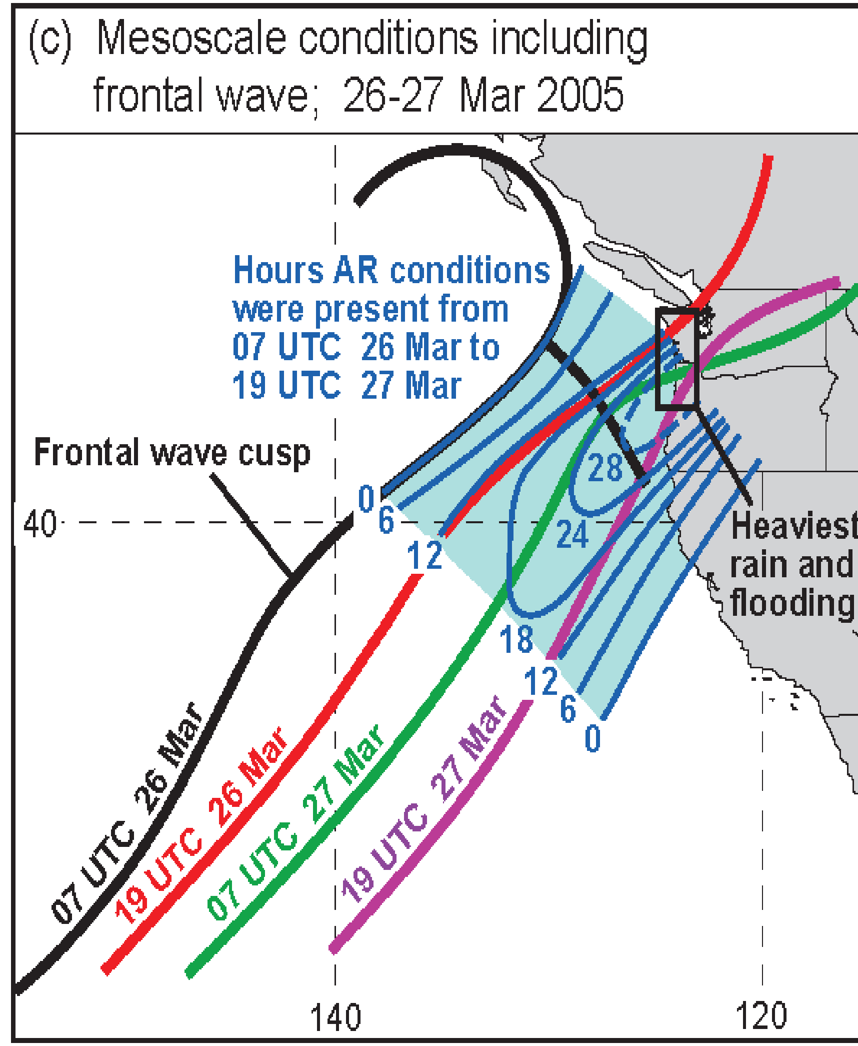
Example from November 7, 2006

Wick et al., 2012, IEEE TGRS, in revision.

Phasing of tropical and extratropical conditions leading to entrainment of tropical water vapor into the AR

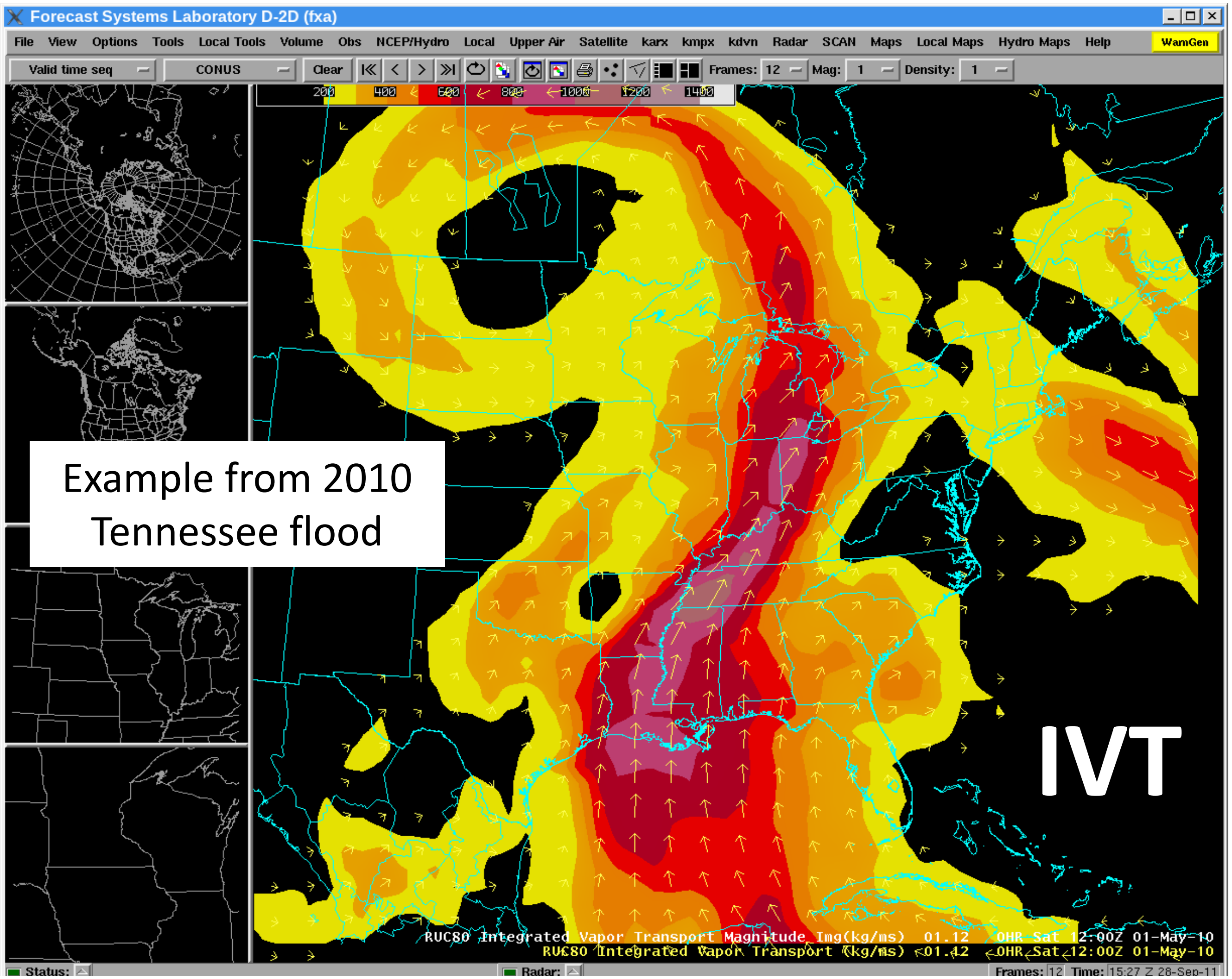
The frontal wave increased the duration of AR conditions where the extreme precipitation occured





Vertically Integrated Vapor Transport (IVT)

A key variable is the vertical integral of the horizontal water vapor transport – called "IVT"



Observations of IVT are available from profiling systems, including dropsondes, radiosondes and AROs, but are not available from satellite.

Model output can be used to calculate maps of IVT, as shown here.

AWIPS Volume Browser can now calculate the IVT by modifying the configuration files per the dan.txt file

Courtesy of B. Motta, M Kelsch, CIMMS

HMT-HPC/ESRL Atmospheric River Retrospective Forecasting Experiment (ARRFEX)

September 17-28, 2012

NOAA Water Cycle Science Challenge Workshop

NOAA Water Cycle Science Challenge Workshop

- **Scope**
  - "Understanding & predicting conditions associated with too much or too little water"
  - Interagency Program Committee: Marty Ralph (NOAA) , Bert Davis (USACE) Co-chairs
  - More than 60 people (1/3 NOAA, 1/3 other Agencies, 1/3 Academic) for 3 days

- **Key Recommendations**
  - Increase hydrologic forecasting skill for low-to-high flow conditions to be as good as the skill afforded by weather and climate predictions
  - Develop a National Water Cycle Reanalysis, including key "forcings" that close the water budget at multiple temporal and spatial scales
  - Diagnose physical processes key to extreme events and document their roles in forecast successes and busts
  - Develop a Hydroclimate Testbed building on NIDIS, HMT, RISAs and Labs that would link hydroclimate science to services and user needs, and emphasizes extremes

Thank You